BACHELOR THESIS – ME184841

ANALYSIS OF PORT-BASED DISCHARGE WATER TREATMENT OF SHIPS, CASE STUDY: TERMINAL PETIKEMAS SURABAYA

Nurkhairana Aryanti Trikurnia
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DEPARTMENT OF MARINE ENGINEERING
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SKRIPSI – ME 184841

ANALISIS INSTALASI PENGOLAHAN AIR LIMBAH KAPAL BERBASIS PELABUHAN, STUDI KASUS: TERMINAL PETIKEMAS SURABAYA

Nurkhairana Aryanti Trikurnia
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INSTITUT TEKNOLOGI SEPULUH NOPEMBER
2019

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APPROVAL FORM

ANALYSIS OF PORT-BASED DICHARGE WATER TREATMENT OF SHIPS, CASE STUDY: TERMINAL PETIKEMAS SURABAYA

BACHELOR THESIS

Submitted to Comply One of the Requirements to Obtain
Bachelor of Engineering Degree
in
Double Degree Marine Engineering (DDME) Program
Undergraduate Program of Marine Engineering
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember
Department of Maritime Studies
Hochschule Wismar, University of Applied Sciences

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APPROVAL SHEET

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Dr. Ing. Wolfgang Busse

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DECLARATION OF HONOR

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This bachelor thesis as been written and developed independently without any plagiarism act. All content and ideas drawn directly from internal and external sources are indicated such as cited sources, literature and other professional sources.

Student Name	: Nurkhairana Aryanti Trikurnia
Student ID	: 04211541000024
Thesis Title	: Analysis of Port-Based Discharge Water Treatment of Ships, Case Study: Terminal Petikemas Surabaya
Department	: Marine Engineering, Double Degree Program

If there is any plagiarism act detected in this thesis, I will be fully responsible and receive the penalty given according to regulation applied.

Surabaya, January 2019

Nurkhairana Aryanti Trikurnia
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Analysis of Port-Based Discharge Water Treatment of Ships, Case Study: Terminal Petikemas Surabaya

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ABSTRACT

90% of world trade is carried by shipping industry. In Indonesia, highly concentrated goods movement are reported in Java and Sumatera which leads Tanjung Perak, Surabaya to become second largest ship terminal after Tanjung Priok, Jakarta. As the loading and unloading process is on call, any kinds of wastewater are continuously being discharged (sludge, oily sludge, blackwater and greywater). All wastewater if continuously discharged without any proper treatment is harmful to both human and aquatic environment. Especially in Indonesia and northern part of Java island where marine tourism is growing but in the other hand, also the home of largest ports. The purpose of this research is to design a fixed, compact discharge water treatment plant in one pilot international terminal, Terminal Petikemas Surabaya. The capacity of each discharge water receiver and treatment is determined according to ship's arrival data. Based on the data analysis, the capacity of sludge receiver is 25 m^3/day, oily bilge receiver for 200 m^3/day, blackwater for 10 m^3/day and greywater for 20 m^3/day. Hereinafter, through the literature review of various kinds of wastewater treatment, a fixed and compact port-based discharge water treatment plant is designed by combining Membrane Bioreactor (MBR) for greywater, centrifugation for sludge, combination of ultrafiltration and reverse osmosis for oily bilge and Source Separation Sanitation (SSS) for blackwater where each effluent of the treatment can be used for one another. Furtheremore, an initial cost of the designed port-based discharge water treatment plant is conducted, resulting in total of IDR 22,487,086,876. The payback period (PBP) of the plant is 4 years.

Keywords : port-based discharge water treatment, ship wastewater, Terminal Petikemas Surabaya.

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Analisis Instalasi Pengolahan Air Limbah Kapal Berbasis Pelabuhan, Studi Kasus: Terminal Petikemas Surabaya

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ABSTRAK

90% dari perdagangan dunia dibawa dan dihantarkan oleh industri perkapalan. Di indonesia, konsentrasi pergerakan arus barang terpusat di daerah sekitar pulau Jawad an Sumatera, yang menjadikan pelabuhan Tanjung Perak Surabaya pelabuhan terbesar kedua setelah Tanjung Priok Jakarta. Saat kapal-kapal sedang bongkar muat, berbagai macam limbah cair yang berasal dari kapal dibuang ke laut (lumpur sisa bahan bakar, genangan air bilga, air buangan toilet (*blackwater*) dan air buangan sabun (*greywater*). Semua jenis limbah cair tersebut jika terus menerus dibuang ke perairan tanpa ada pengolahan terlebih dahulu akan berdampak bahaya bagi manusia dan lingkungan. Khususnya di Indonesia dan wilayah utara pulau Jawa dimana wisata perairan sedang dibangun namun juga merangkap sebagai pusat pelabuhan-pelabuhan besar. Tujuan dari penelitian ini adalah untuk merancang sebuah instalasi pengolahan air limbah kapal berbasis pelabuhan pada satu terminal percontohan, yaitu Terminal Petikemas Surabaya. Kapasitas setiap jenis air limbah ditentukan dari data kedatangan kapal. Berdasarkan analisis data yang telah dilakukan, didapatkan volume pengolahan *sludge* sebesar 25 m^3/hari, air bilga sebesar 200 m^3/hari, *blackwater* sebesar 10 m^3/hari dan *greywater* sebesar 20 m^3/hari. Selanjutnya, melalui kajian pustaka dari berbagai jenis pengolahan, instalasi pengolahan air limbah kapal berbasis pelabuhan di Terminal Petikemas Surabaya dirancang dengan menggabungkan *Membrane Bioreactor* (MBR) untuk *greywater*, sentrifugasi untuk *sludge*, kombinasi ultrafiltrasi dan *reverse osmosis* untuk genangan air bilga dan *Source Separation Sanitation* (SSS) untuk *blackwater* dimana setiap keluaran dari pengolahan dapat digunakan kembali. Setelah itu, dilakukan perkiraan biaya pembangunan instalasi pengolahan air limbah dari alat-alat yang ada pada sistem, menghasilkan kisaran biaya IDR 22, 487,086,876. Periode pengembalian investasi (*payback period*) instalasi ini adalah 4 tahun.

Kata kunci : Instalasi pengolahan air limbah berbasis pelabuhan, limbah kapal, Terminal Petikemas Surabaya.

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PREFACE

The author would like to bestow massive thanks to Allah SWT and the Great Prophet Mohammad, for the last six month full of learning and process. This bachelor thesis titled **"Analysis of Port-Based Discharge Water Treatment Plant, Case Study: Terminal Petikemas Surabaya"** has finally finished, in the middle of heavy rain, in late January 2019. A lot of effort was needed to finish this last assignment given before officially bear the title Bachelor of Engineering. Hours of research were spent, often in the most perplexing way possible. Despite the hard times, the author has finished this bachelor thesis. Therefore, the author would like to thank:

1. The author's family, parents Dwi Aryo Putro and Widajanti Purnomosari who always been in endless support of financial and emotional, having spending hours of praying in the middle of the night. And siblings Nisa Adani Dwikurnia and Zalfa Catur Kurnia who always been putting her personal interest aside and put mine instead.
2. Taufik Fajar Nugroho, S.T., M.Sc. as the author's guardian lecturer and also the author's first supervisor of Bachelor Thesis who has been guiding and guarding the author in her 3.5 years of college life.
3. Ir. Alam Baheramsyah, M.Sc. as the author's second supervisor who has been super patient and the true definition of a man full of wisdom.
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6. Mas Alif Yudha Ashari who has been the author's closest friend, debate partner and brother for two years (and still counting). Will never make it until this stage in his absent. Thank you for replacing and repairing the definition of 'college friend', restoring the author's faith in humanity.
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8. Beloved Ryanmizar, Natasya and Billa who stick with me during the hard(s) and easy(s).
9. Seven fat, lazy cats: Gendut, Unyil, Pesek, Belang, Tompel, Itheng and Kunti. It was quite *impossible* for the author to finish her college on time without their presence in the author's daily life. They are simply the author's reason to come home.

10. The author’s furry kids: in memoriam Cika, beloved Loreng, Catur, Ares, Thalia, Beti, Thor and Batman who put clearer mind and more peaceful mood after feeding them and cleaning their litter boxes.
11. Beloved Titans’15, forever best friends in world and (inshaAllah) afterlife.
12. Beloved Salvage ’15, Barakuda ’13, Mercusuar ’14, Voyage’16, Badrikara ’17 who brought colors to the author’s college life.

The writer realizes that this bachelor thesis is still far from perfect. Some further researches have to be conducted in order to fix and deepen the discussion brought by this bachelor thesis. Any critics and suggestions are welcome.

Surabaya, 28 January 2019

Nurkhairana Aryanti Trikurnia
NRP. 04211541000024

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CHAPTER I
INTRODUCTION

I.1. Background

Maritime sector is the busiest sector in the world, including shipping industry, sea transportation and even mining activities such as fuel exploration. 90% of world trade is carried by shipping industry and over 50,000 merchant ships are transporting any kind of cargo worldwide (International Chamber of Shipping, 2018). As for Indonesia, highly concentrated goods movement are reported in Java and Sumatera (National Development Planning Agency (BAPPENAS), 2013). This phenomenon leads Tanjung Perak, Surabaya to become second largest ship terminal in Indonesia.

Tanjung Perak, Surabaya is not only dealing with domestic goods movement, but also one of the busiest port dealing with international goods trade in Indonesia. One of several international terminals in Tanjung Perak Surabaya, PT. TPS (Terminal Petikemas Surabaya) recorded that more than a thousand of international-sailing ships entered the terminal of TPS per 2017, loading and unloading for about tens of thousands container per month (PT. TPS, 2017).

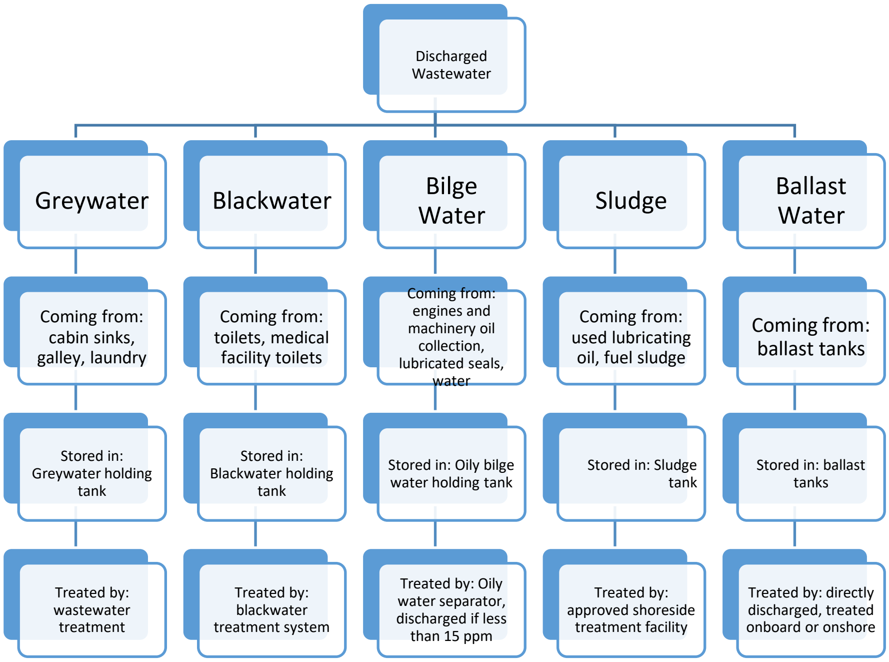

Fig.1.1. Types of Discharged Water from Ships
(Source: private document)

Taking this into account, as the loading and unloading process is on call, wastewater is continuously being discharged. There are five kinds of discharged wastewater coming from ship's hull: ballast water, sludge, oily bilge water, greywater and blackwater. Sludge is originated from fuel oil and lubricating oil separation activity and stored in sludge tank before discharging into the sea or onshore. Bilge water is originated from the puddle on bilge area, mainly in machinery space. Sewage which is divided into two categories: greywater and blackwater, originated from greywater and blackwater holding tank consisting human feces and urines. Ballast water is used for keeping the ship's stability during loading and unloading the cargo. The illustration on Fig.1.1 explains and differs discharged wastewater coming from ships.

Sludge which is originated from fuel sludge and used lubricating oil is prohibited to be discharged directly into the sea. The sludge is totally harmful to ocean environment and a high pollutant for aquatic ecosystem. Therefore, it should be discharged to Port Reception Facilities or incinerated onboard.

On the other hand, sewage which is originated from blackwater holding tank and greywater holding tank can be discharged directly to the sea at a distance of more than 12 nautical miles from the nearest land. As for disinfected sewage using a system approved by the Administration, it can be discharged at least 3 nautical miles from the nearest land.

As for oily bilge originated from ship's bilge and stored in oily bilge water holding tank, only water with the maximum oil content of 5 ppm can be directly discharge into the sea. The oily bilge is accumulated mainly under the machinery spaces, acts as a 'reservoir' to the leakages. Since the working fluids in the machinery spaces are oils, it is not a surprise if the bilge water is highly contaminated with oil drips from fuel and lubricating oil.

However, ballast water and its impact have been a warm topic among ocean environmentalists and also, IMO (International Maritime Organization). Numerous researches regarding the best method applicable to treat ballast water has been carried out. Many ships have been equipped with ballast water treatment onboard. Meanwhile, the other discharge water is usually directly discharged into the sea, or, in some cases, collected onshore and transported to urban water treatment for further treatment. Therefore, in this bachelor thesis, the compact, fixed water treatment plant placed in port will be designed to facilitate the discharge water coming from ships.

Fig.1.2. Indonesia Marine Tourism Destination Growth According to PP 50/2011 (Image source: *https://www.slideshare.net/fitriwardhono/pengembangan-pariwisata-bahari*)

All four kinds of wastewater discharged from ships, if directly and continuously discharged into the open sea, will harm both the aquatic and human environment. Especially in Indonesia as an archipelagic country which has the total water area of 6.315.222 km2, 99.093 km2 long of coastline and total of 13.466 islands (Badan Informasi Geospasial, 2015). Furthermore, Indonesia has developed future plan to grow its marine tourism, taking the advantage of having second longest coastline in the world. Fig.1.2. illustrates the marine tourism development of Indonesia.

In this bachelor thesis, the author proposes a preventive action to treat those wastewater discharged by the ships. To benefit both shipowner as a 'polluters' and local government to keep the aquatic environment clean, a pilot design of a compact, fixed water treatment plant is designed.

I.2. Problem Statement

There are several key points of the bachelor thesis to be exerted:

1. What is the adequate capacity of sludge receiver?
2. What is the adequate capacity of oily bilge receiver?
3. What is the adequate capacity of blackwater receiver?
4. What is the adequate capacity of greywater receiver?
5. How is the design of wastewater treatment plant according to the receiver's adequate capacity and free space provided in the terminal?
6. How is the economic analysis of the plant?

I.3. Disclaimer

The analysis of port-based discharge water treatment plant has to be carried out in specific area, therefore, some disclaimers are needed in order to limit the experiment scope:

1. Location of the port-based discharge water treatment plant will be overviewed at TPS (Terminal Petikemas Surabaya).
2. The data will be analyzed from ship arrival record in the year of 2017.

I.4. Objectives

The objectives of this bachelor thesis are:

1. To determine the adequate capacity of sludge receiver.
2. To determine the adequate capacity of oily bilge receiver.
3. To determine the adequate capacity of blackwater receiver.
4. To determine the adequate capacity of greywater receiver.
5. To design the discharge water treatment plant according to the receiver's adequate capacity and free space provided in the terminal
6. To analyze the economic analysis of the port-based discharge water treatment plant.

I.5. Benefits

The benefits of this bachelor thesis are to:

1. Introducing a new way of port-based discharge water treatment system as a part of Port Reception Facility.
2. Comes up as a reference which can be used in another ports.

CHAPTER II
LITERATURE REVIEW

II.1. Ship Discharge Water Requirement

The discharge of ‘dirty’ or ‘contaminated’ water which is responsible for marine pollution if discharged on open sea other than ballast water mainly refers to oil pollution produced by oil tankers. In this case study – where the port is designed to receive container ships – will not focus on the matter of slop tanks cleaning and any other big-scaled oily water discharge to be treated in the port reception facilities.

However, based on regulation 17 of MARPOL Annex I, every ship for 400 tons gross tonnage and above shall be provided with a tank or tanks of adequate capacity, having regard to the type of machinery and length of voyage, to receive the oil residues (sludge) which cannot be dealt with other wise in accordance with the requirement of this Annex, such as those resulting from the purification of fuel and lubricating oils and oil leakages in the machinery spaces. In new ships, such tanks shall be designed and constructed so as to facilitate their cleaning and the discharge of residues to reception facilities. Existing ships shall comply with this requirement as far as is reasonable and practicable.

Regulation 9 of this Annex also prohibit any discharge of oily bilge water from any ships of 400 gross tonnage and above which comes from machinery spaces and exceeds 15 parts per million (ppm) of oil content into the open sea.

II.2. Port Reception Facilities

The term reception facilities refers to any fixed, floating or mobile facility capable or receiving MARPOL residues/wastes from ships and fit for that purposes. In view of the need to tackle the long-standing problem of the inadequacy of port reception facilities, the Marine environment Protection Committee (the Committee), having received valuable input from the Industry Port Reception Facilities Forum, adopted, at its fifty-fifth session (October 2006), the Action Plan on Tackling the Inadequacy of Port Reception Facilities and instructed the Sub-Committee on Flag State Implementation (FSI) to progress the Plan’s work item .

The use and provision of Port Reception Facilities (PRFs) is fundamental to the overall success of the International Convention for the Prevention of Pollution from Ships (MARPOL) in its objective of reducing and ultimately eliminating intentional pollution of the marine environment by ships. Considerable efforts by Party States and the industry have resulted in an improvement in the availability and adequacy of PRFs.

Keeping the seas and oceans clean should be seen as the overriding obligation for the use and provision of PRFs. MARPOL includes regulations aimed at preventing and minimizing pollution from ships – both accidental pollution and that from routine operations. The basis for providing and using PRFs is incorporated in the Annexes of MARPOL and implementing laws and regulations of State Parties. The following summarizes the basic obligations under MARPOL and includes other considerations that ship and port operators should take into account. For specific legal requirements, users of this Guidance should refer directly to the MARPOL Protocols and Annexes or implementing regulations of individual States Party to the Convention.

The Port Reception Facilities (PRF) accepts any kind of discharge and garbage. Discharge as defined in MARPOL as any release howsoever caused from a ship and includes any escape, disposal, spilling, leaking, pumping, emitting or emptying. The term "discharge" refers generally to the types of discharges that are regulated under MARPOL. Meanwhile garbage as defined in MARPOL Annex V, means all kinds of food wastes, domestic wastes and operational wastes, all plastics, cargo residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in other Annexes to the Convention.

In this bachelor thesis which takes case study of Terminal Petikemas Surabaya, will be focusing on its water treatment on Port Reception Facilities. Therefore, the analysis of water treatment in Port Reception Facilities of TPS will take the term discharge as its object.

MEPC in 2000 adopted resolution MEPC. 83(44) which stated that adequate facilities can be defined as those which:

- Mariners use;
- Fully meet the needs of the ships regularly using them;
- Do not provide mariners with a disincentive to use them
- Contribute to the improvement of the marine environment;
- Meet the need of the ships normally using the port; and
- Allow for the ultimate disposal of ship's wastes to take place in an environmentally appropriate way.

II.3. Oily Sludge Composition

The composition of oily sludge is complex. It comprises of oil in water, water in oil emulsion and suspended solids. Oily sludge contains toxic substances like aromatic hydrocarbons, polyaromatic hydrocarbons and high total hydrocarbons content. Oily sludge is difficult to be hydrated due to its high viscosityOily sludge basically comprises of about 55.13% of water, 9.246% of sediments, 1.9173% of asphaltenes, 10.514% of wax and 23.19% of light hydrocarbons and also a high concentration of heavy metals for instance vanadium is 204 ppm, Fe is 0.6% and nickel is 506 ppm4, which makes the oily sludge harmful for the environment and organisms, which need to be dealt with, for environmental protection.

Petroleum sludge is classified as hazardous waste (usually due to the oil content) and in most cases, it is also classified as a liquid, which means that it cannot be disposed directly to a landfill.

II.4. Sludge Treatment Methods

The various technologies for oil recovery and redemption of the crude sludge include chemical treatments, centrifugation, various distillation processes, cracking, hydro-treating, solvent treatment and bioremediation. Some of the conventional methods of sludge treatment are as follows:

A. Solvent extraction method

Various solvents are used in this method, which are able to break down complex molecules present in the sludge into their basic constituents - water, crude oil and particulate. This method requires mixing and agitation apparatus (Fig.2.5). Sludge has waxy and non waxy (asphaltenes) organic components along with salt, oxides and other inorganic materials. These may be dissolved by selecting appropriate solvent.

Oily sludge waste is firstly mixed in the reactor column with a solvent, which selectively dissolves the oil fraction of sludge and leaves the less soluble impurities at the column bottom. The oil solvent solution is then transferred to a solvent distillation system where the solvent is separated from oil. The separated oil is considered as oil recovery, while the separated solvent vapour can be liquefied through a compressor and cooling system and sent to a solvent recycling tank. The solvent can be used for repeating the extraction cycle. The bottom impurities from reactor column are pumped to a second distillation system, and the solvent contained in the impurities is separated and then sent to the solvent recycling tank, while the waste residues after separation may need further treatment. The solvent extraction method flow diagram is shown on the Figure.2.1.

B. Ultra high temperature gasification

In this method, thermal oxidation of sludge is carried out. The sludge is heated to a very high temperature (1000oC) using plasma arc without oxygen. The sludge is converted to pyrogas by this method and this can be used as fuel.

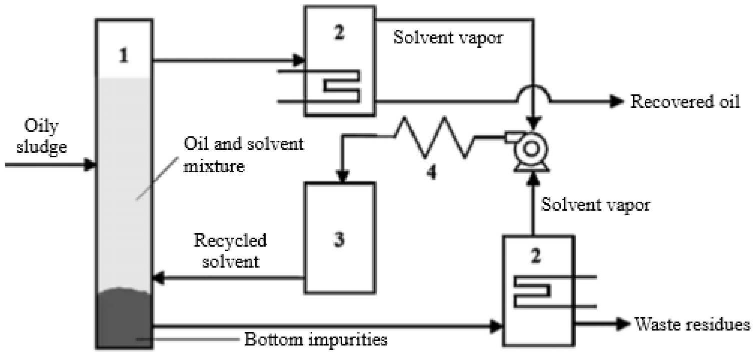

Fig.2.1. Backflow diagram of solvent extraction method
(Source: Petroleum Sludge, Its Treatment and Disposal: A Review, Badrul Islam, 2015)

C. Centrifugation Method

Centrifugation method using centrifuges to separate fluids based by their densities whether it is water, solids, oil and pasty mixtures. First, sludge is inserted into pre-treatment tank, which is purposed to reduce its viscosity by adding solvents, demulsifying agent and steam for heating. Once the viscosity of the sludge is reduced, the less viscous sludge is pumped into the centrifuge. The centrifuge then separates oily mixtures, oily wastewater and waste solids. The oil phase then purified further using gravimetric separator to produce recovered oil and separate solids. The wastewater then goes into wastewater treatment unit while waste solids will be sent to landfill (Islam, 2015).

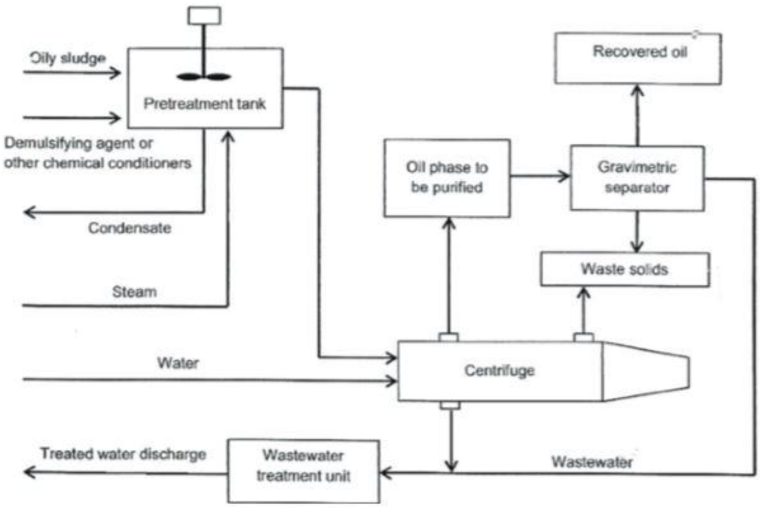

Fig.2.2. Schematic diagram of centrifugation method
(Source: Petroleum Sludge, Its Treatment and Disposal: A Review, Badrul Islam, 2015)

II.5. Oily Bilge Composition

The oily bilge coming from engine room of the ships consists of different kinds of water contaminants which mostly dominated by oil leakage from fuel and lubrication of the machineries. The composition is built by oily wastewater and oil-water emulsion.

Emulsified oily wastewater can contain oil (mineral, vegetable or synthetic), fatty acids, emulsifiers (anionic and nonionic surfactants), corrosion inhibitors (amines), bactericides and other chemicals designed to provide a long-lasting and effective fluid. Many fluids have very stable emulsion, which make chemical treatment difficult. Since the oil is chemically emulsi- fied, normal separation processes (gravity, flotation, skimming) are not effective. The standard methods for treatment of emulsified oily wastewater is chemi- cal de-emulsification followed by secondary clarifica- tions, which requires the use of a variety of chemicals such as sulphuric acid, iron and alumina sulphates, etc. The water phase from chemical treatment has to be further purificated to meet today's effluent stan- dard for discharge systems.

II.6. Oily Bilge Treatment Methods

To solve the problem with stable emulsion and oily wastewaters, new, effective methods have recently been elaborated. Biotechnology offers some new approaches, based on biodegradation and biotransfor- mation of fats and oily wastes. The most promising methods, based on membrane separation processes are: the dehydration of oil emulsion via pervaporation, reverse osmosis, ultrafiltration, membrane extraction for fat removal, and application of an electric field to coalesce the droplets. The separation of oil in wastewater from engine-rooms may be performed by ultrafiltration WF), a pressure-driven membrane process which can separate, concentrate and fractionate macromolecular solutes and suspended species from water. The ultrafiltration method of treatment produces a water phase which is generally of acceptable quality for direct sewer discharge into the sea, and an oil phase that can be incinerated. If further treatment of the permeate is required, there are several effective posttreatment methods. For example, stream discharge standards would normally require posttreatment of the permeate by: biological treatment, activated carbon, reverse osmosis and carbonaceous resins. Reverse osmosis (RO) and activated carbon treatment will permit reuse of the treated water as process water.

II.7. Blackwater Composition

As presented by Kujawa-Roeleveld and Zeeman (2006), human feces contains 28% of the total phosphorous and 13% of the total nitrogen, respectively. Nitrogen (N) and prosphorous (P) are two nutrients which recycled avoiding not only eutrophication or pollution potential but can be reused, contributing to their sustainability.

II.8. Blackwater Treatment Methods

There are several blackwater treatment methods available in sophisticated technologies. However, some treatment methods only applicable in large scale while some only serve small-scale. In this bachelor thesis, the SSS (source separation sanitation) is used.

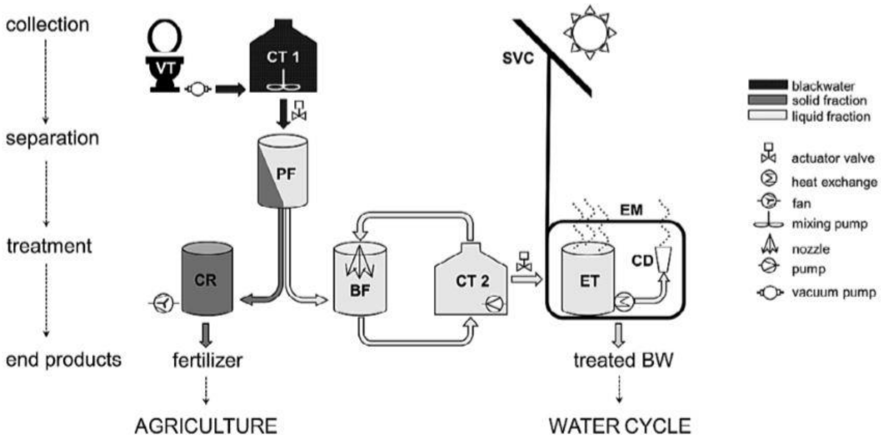

Fig.2.3. SSS (source separation sanitation) scheme
(Source: (Oarga-Mulec, Jenssen, Klemencic, Ursic, & Bulc, 2017)

II.9. Greywater Composition

Greywater comes from household discharge water, in this case, greywater discharged from ships comes from galley sink, washbasin, bathroom and laundry which doesn't consist urine and feces. The capacity of greywater is also much bigger than blackwater's.

The contaminants which highly present in greywater are detergent/soap, oil and grease, gastrointestinal fluids, organic substances, alkaline salts, fluorides, semi solids and suspended solids. Detergent, oil & grease and suspended solids are major contaminant in washing machine's discharge water. Semi solids, oil & grease, organic substances and soap are major contaminant coming from galley sinks. Semi solids, detergent, alkaline salts, organic substances and gastrointestinal fluids are major contaminant of bathroom sinks (Ashok, Kumar, & Bhalla, 2018).

The characteristics of greywater depends highly on the consumption & living style of the user. In previous researches, the mean range of some pollutant concentrations in domestic greywater were found as follows: pH 6-9, turbidity 12-2131 NTU, conductivity 1.4 – 703 mS/m, total suspended solids (TSS) 11-2180 mg/L, biochemical oxygen demand (BOD) 23-942 mg/L, chemical oxygen demand (COD) 55-2000 mg/L, methylene blue active substance (MBAS) 0.3 – 118 mg/L, oil and grease (O&G) 7-328 mg/L, total P 0.012-51.58 mg/L, PO_4-P 0.53-1.21 mg/L, total N 1.1-40.3 mg/L, NO_3-N 0.93-6.6 mg/L, NO_2-N 0.1-0.36 mg/L, total coliforms (TC) 200-2.2 x 10^7 MPN, faecal coli forms (FC) 13-1.9x10^7 MPN and *Escherecia coli* 10-3.9x10^5 MPN (Barisci & Turkay, 2016).

II.10. Greywater Treatment Methods

There are two main methods in treating greywater. First is using CAS (Conventional Activated Sludge) and the other is using MBR (Membrane Bioreactor).

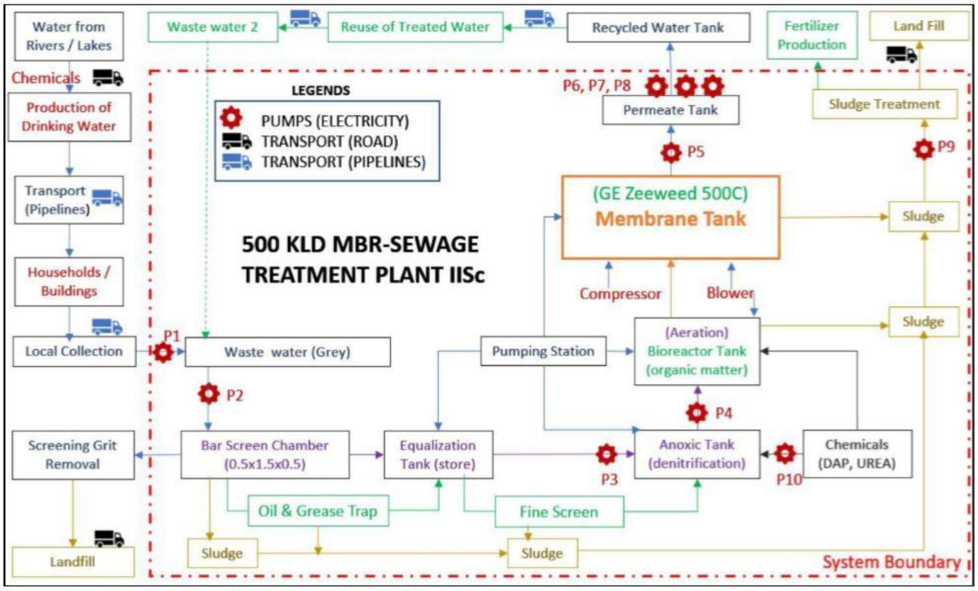

Fig.2.4. Example of Membrane Bioreactor (MBR)
(Source: Integrated Greywater Management Systems: A Design Proposal for Efficient and Decentralised Greywater Sewage Treatment, Ashok et. al, 2018)

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CHAPTER III
RESEARCH METHODOLOGY

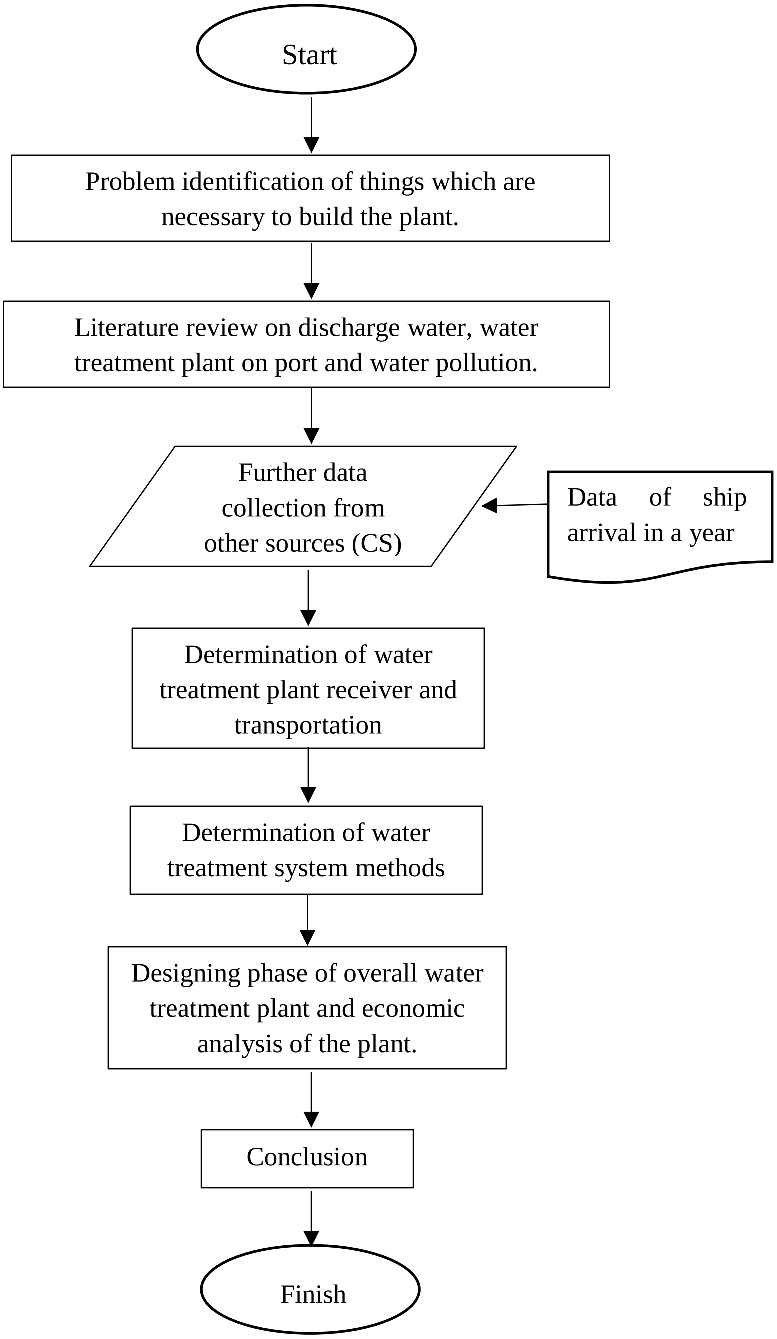

Fig.3.1. Research methodology flowchart

III.1. Data Collection

The data needed is collected from ship arrival in a year. This bachelor thesis started from August 2018, therefore, the detailed data available from the terminal is from January until December 2017. The data obtained from the terminal consists of:

1. Ship's name
2. Port of origin
3. Time berthing
4. Time departure

These data needs more information before being analyzed. Further information regarding the ships can be found in its classification society ship list.

III.2. Analysis on Water Treatment Plant

III.2.1. Determination of discharge water receiver capacity

The determination of discharge water receiver capacity is necessary to be analyzed as the first step of designing overall port-based discharge water treatment plant. To do so, we need the information about how many m^3 of discharge water is discharged per day. The determination of discharge water receiver capacity can be done in several steps:

1. Determine each ship's discharge water holding tank (sludge tank, oily bilge holding tank, greywater holding tank and blackwater holding tank).
2. Record the ship arrival per day.
3. Determine the discharge water per day by totaling the volume of holding tanks of all ships which arrived in that day.
4. By completing the information of each day's discharge water volume for a whole year, average, maximum and minimum volume per day can be determined.

III.2.2. Determination of water treatment plant transportation

The meaning of this step is to determine the mode of transportation which will be used in handling the discharge water from ship to the plant. The port-based discharge water treatment plant is designed as fixed platform and not portable, because the aim of the design is to minimalize the waste and maximize the reusable materials after the treatment.

The mode of transportation is determined by each kind of discharge water's compiled volume. It is more economically effective to use trucks to transport a little volume of discharge water and use pipelines to transport large volume of discharge water.

III.2.3. Determination of water treatment system methods

Different kind of ship discharge water treatment cannot be treated by the same method. Therefore, different treatment method is reviewed for different kind of discharge water. The treatment system which produces the least cannot-be-reused effluent is chosen. The treatment system chosen also considers the capacity of the volume. For example, the volume of oily bilge collected in container terminal is not as large as collected in tanker terminal. Thus, several methods of treating oily bilge water in tanker terminal is not economically effective to be used in container terminal.

III.2.4. Designing overall water treatment plant and its economic analysis

The overall design of discharge water treatment plant combines all chosen discharge water treatment. Some product of one treatment may be used in other treatment or used in other unit. For example, the reusable water from greywater treatment plant can be used for water the plants or filling the office's daily need of toilet flushing.

The economic analysis consists of BOQ (Bill of Quantity) which can be determined by totaling overall system's main equipment and transportation modes, and investment evaluation. In BOQ, however, plant building cost is excluded from detail list in this bachelor thesis and be put in estimation percentage. As for investment evaluation, this bachelor thesis uses PBP (Payback period).

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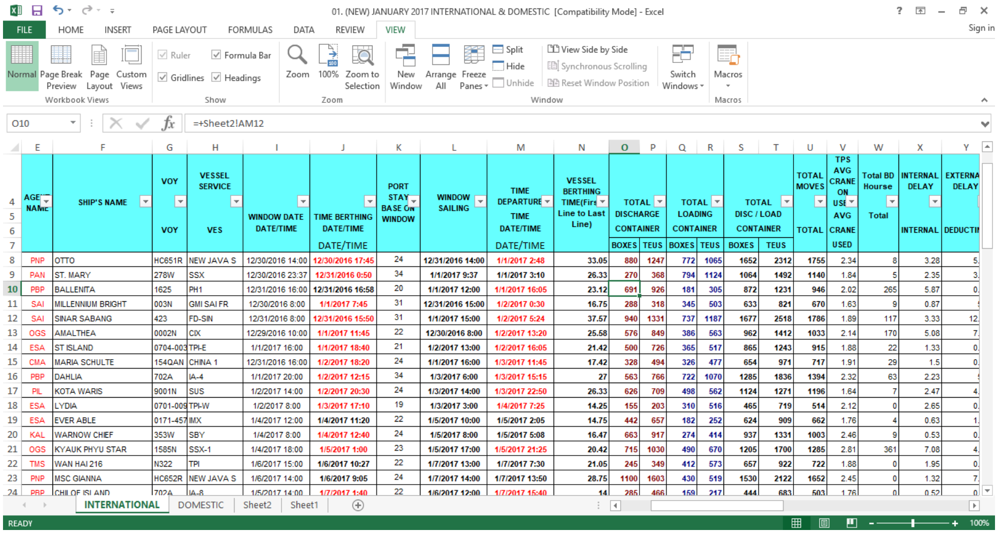
CHAPTER IV
EXPLORATION

IV.1. Determining Adequate Sludge Receiver

Before determining the most suitable method of sludge treatment which will be discussed in IV.5, the adequate capacity of sludge receiver has to be calculated first according to ship arrival per day.



	AGENT NAME	SHIP'S NAME	VOY	VESSEL SERVICE / VES	WINDOW DATE DATE/TIME	TIME BERTHING DATE/TIME	PORT STAY BASE ON WINDOW	WINDOW SAILING	TIME DEPARTURE TIME DATE/TIME	VESSEL BERTHING TIME(First Line to Last Line)	TOTAL DISCHARGE CONTAINER BOXES	TOTAL DISCHARGE CONTAINER TEUS	TOTAL LOADING CONTAINER BOXES	TOTAL LOADING CONTAINER TEUS	TOTAL DISC / LOAD CONTAINER BOXES	TOTAL DISC / LOAD CONTAINER TEUS	TOTAL MOVES TOTAL	TPS AVG CRANE ON USE AVG CRANE USED	Total BD Hourse Total	INTERNAL DELAY INTERNAL	EXTERNAL DELAY DEDUCTION
8	PNP	OTTO	HC651R	NEW JAVA S	12/30/2016 14:00	12/30/2016 17:45	24	12/31/2016 14:00	1/1/2017 2:48	33.05	880	1247	772	1065	1652	2312	1755	2.34	8	3.28	5.
9	PAN	ST. MARY	278W	SSX	12/30/2016 23:37	12/31/2016 0:50	34	1/1/2017 9:37	1/1/2017 3:10	26.33	270	368	794	1124	1064	1492	1140	1.84	5	2.35	3.
10	PBP	BALLENITA	1625	PH1	12/31/2016 16:00	12/31/2016 16:58	20	1/1/2017 12:00	1/1/2017 16:05	23.12	691	926	181	305	872	1231	946	2.02	265	5.87	0.
11	SAI	MILLENNIUM BRIGHT	003N	GMI SAI FR	12/30/2016 8:00	1/1/2017 7:45	31	12/31/2016 15:00	1/2/2017 0:30	16.75	288	318	345	503	633	821	670	1.63	9	0.87	[illegible]
12	SAI	SINAR SABANG	423	FD-SIN	12/31/2016 8:00	12/31/2016 15:50	31	1/1/2017 15:00	1/2/2017 5:24	37.57	940	1331	737	1187	1677	2518	1786	1.89	117	3.33	12.
13	OGS	AMALTHEA	0002N	CIX	12/29/2016 10:00	1/1/2017 11:45	22	12/30/2016 8:00	1/2/2017 13:20	25.58	576	849	386	563	962	1412	1033	2.14	170	5.08	7.
14	ESA	ST ISLAND	0704-003	TPI-E	1/1/2017 16:00	1/1/2017 18:40	21	1/2/2017 13:00	1/2/2017 16:05	21.42	500	726	365	517	865	1243	915	1.88	22	1.33	0.
15	CMA	MARIA SCHULTE	154QAN	CHINA 1	12/31/2016 16:00	1/2/2017 18:20	24	1/1/2017 16:00	1/3/2017 11:45	17.42	328	494	326	477	654	971	717	1.91	29	1.5	0.
16	PBP	DAHLIA	702A	IA-4	1/1/2017 20:00	1/2/2017 12:15	34	1/3/2017 6:00	1/3/2017 15:15	27	563	766	722	1070	1285	1836	1394	2.32	63	2.23	[illegible]
17	PIL	KOTA WARIS	9001N	SUS	1/2/2017 14:00	1/2/2017 20:30	24	1/3/2017 14:00	1/3/2017 22:50	26.33	626	709	498	562	1124	1271	1196	1.64	7	2.47	4.
18	ESA	LYDIA	0701-009	TPI-W	1/2/2017 8:00	1/3/2017 17:10	19	1/3/2017 3:00	1/4/2017 7:25	14.25	155	203	310	516	465	719	514	2.12	0	2.65	0.
19	ESA	EVER ABLE	0171-457	IMX	1/4/2017 12:00	1/4/2017 11:20	22	1/5/2017 10:00	1/5/2017 2:05	14.75	442	657	182	252	624	909	662	1.76	4	0.63	1.
20	KAL	WARNOW CHIEF	353W	SBY	1/4/2017 8:00	1/4/2017 12:40	24	1/5/2017 8:00	1/5/2017 5:08	16.47	663	917	274	414	937	1331	1003	2.46	9	0.53	0.
21	OGS	KYAUK PHYU STAR	1585N	SSX-1	1/4/2017 18:00	1/5/2017 1:00	23	1/5/2017 17:00	1/5/2017 21:25	20.42	715	1030	490	670	1205	1700	1285	2.81	361	7.08	4.
22	TMS	WAN HAI 216	N322	TPI	1/6/2017 15:00	1/6/2017 10:27	22	1/7/2017 13:00	1/7/2017 7:30	21.05	245	349	412	573	657	922	722	1.88	0	1.95	0.
23	PNP	MSC GIANNA	HC652R	NEW JAVA S	1/6/2017 14:00	1/6/2017 9:05	24	1/7/2017 14:00	1/7/2017 13:50	28.75	1100	1603	430	519	1530	2122	1652	2.45	0	1.32	7.
24	PBP	CHILOE ISLAND	702A	IA-8	1/5/2017 14:00	1/7/2017 1:40	22	1/6/2017 12:00	1/7/2017 15:40	14	285	466	159	217	444	683	503	1.76	0	0.52	0.

Fig.4.1. Layout of Ship Arrival Raw Data
(Source: TPS, 2017)

The approximate sludge volume discharged can be known from ship arrival data. However, since the raw data does not provide the actual sludge volume discharged, several steps have to be taken in order to determine the volume.

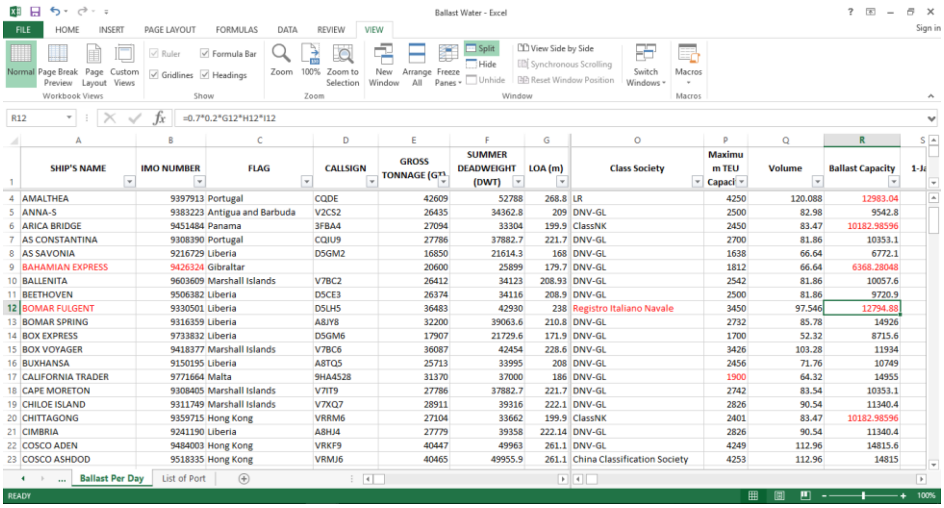
IV.1.1. Completing Ship's Principal Dimensions

Before completing ship's principal dimensions, the summary of all ship call in one year has to be arranged. One ship may arrives several time in a month while another one only comes once a year. Therefore, to avoid repetition of the ship arrival data in completing ship's principal dimensions, it has to be summarized. The ship's principal dimensions can be known from the ship's Classification Society.

The principal dimensions which can be obtained from the Classification Society are:

1. IMO Number
2. Flag & Callsign
3. Gross Tonnage (GT)
4. Deadweight (DWT)

5. LOA (Length Overall)
6. Breadth
7. Draught
8. Year Built
9. Propulsion Engine Brand
10. Propulsion Engine Model (DNV-GL)
11. Maximum TEU Capacity (DNV-GL & ClassNK)



	SHIP'S NAME	IMO NUMBER	FLAG	CALLSIGN	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Class Society	Maximum TEU Capaci	Volume	Ballast Capacity	1-Ja
4	AMALTHEA	9397913	Portugal	CQDE	42609	52788	268.8	LR	4250	120.088	12983.04	
5	ANNA-S	9383223	Antigua and Barbuda	V2CS2	26435	34362.8	209	DNV-GL	2500	82.98	9542.8	
6	ARICA BRIDGE	9451484	Panama	3FBA4	27094	33304	199.9	ClassNK	2450	83.47	10182.98596	
7	AS CONSTANTINA	9308390	Portugal	CQIU9	27786	37882.7	221.7	DNV-GL	2700	81.86	10353.1	
8	AS SAVONIA	9216729	Liberia	D5GM2	16850	21614.3	168	DNV-GL	1638	66.64	6772.1	
9	BAHAMIAN EXPRESS	9426324	Gibraltar		20600	25899	179.7	DNV-GL	1812	66.64	6368.28048	
10	BALLENITA	9603609	Marshall Islands	V7BC2	26412	34123	208.93	DNV-GL	2542	81.86	10057.6	
11	BEETHOVEN	9506382	Liberia	D5CE3	26374	34116	208.9	DNV-GL	2500	81.86	9720.9	
12	BOMAR FULGENT	9330501	Liberia	D5LH5	36483	42930	238	Registro Italiano Navale	3450	97.546	12794.88	
13	BOMAR SPRING	9316359	Liberia	A8JY8	32200	39063.6	210.8	DNV-GL	2732	85.78	14926	
14	BOX EXPRESS	9733832	Liberia	D5GM6	17907	21729.6	171.9	DNV-GL	1700	52.32	8715.6	
15	BOX VOYAGER	9418377	Marshall Islands	V7BC6	36087	42454	228.6	DNV-GL	3426	103.28	11934	
16	BUXHANSA	9150195	Liberia	A8TQ5	25713	33995	208	DNV-GL	2456	71.76	10749	
17	CALIFORNIA TRADER	9771664	Malta	9HA4528	31370	37000	186	DNV-GL	1900	64.32	14955	
18	CAPE MORETON	9308405	Marshall Islands	V7IT9	27786	37882.7	221.7	DNV-GL	2742	83.54	10353.1	
19	CHILOE ISLAND	9311749	Marshall Islands	V7XQ7	28911	39316	222.1	DNV-GL	2826	90.54	11340.4	
20	CHITTAGONG	9359715	Hong Kong	VRRM6	27104	33662	199.9	ClassNK	2401	83.47	10182.98596	
21	CIMBRIA	9241190	Liberia	A8HJ4	27779	39358	222.14	DNV-GL	2826	90.54	11340.4	
22	COSCO ADEN	9484003	Hong Kong	VRKF9	40447	49963	261.1	DNV-GL	4249	112.96	14815.6	
23	COSCO ASHDOD	9518335	Hong Kong	VRMJ6	40465	49955.9	261.1	China Classification Society	4253	112.96	14815	

Fig.4.2. Layout of Ship Principal Dimension Summary

IV.1.2. Determining the Sludge Tank Capacity of Each Ship

For ships which do not carry ballast water in oil fuel tanks, the minimum sludge tank capacity (V_1) should be calculated by the following formula:

$$V_1 = K_1 CD$$

Where:

K_1 = 0.01 for ships where heavy fuel oil is purified for main engine use, or 0.005 for ships using diesel oil or heavy fuel oil which does not require purification before use

C = daily fuel oil consumption (m^3)

D = maximum period of voyage between ports where sludge can be discharged ashore (days). In the absence of precise data a figure of 30 days should be used.

To determine the volume of the sludge tank, at least the data of maximum period of voyage between ports – or in this case, period of voyage between port of origin and TPS Tanjung Perak Surabaya should be known. The period (days) of the voyage can be calculated by the following formula:

$$Time\ (hour) = \frac{Distance\ (nautical\ miles)}{Speed\ (knot)}$$

The distance from the port of origin to Tanjung Perak, Surabaya can be known from online distance measurer website, and the average speed can be known from online record.

After determining the period of the voyage, the estimation of daily fuel oil consumption has to be calculated. The daily fuel oil consumption can be calculated by the following formula:

$$C = \frac{\frac{SFOC\ x\ Engine\ Power}{1000}}{991kg/m^3}$$

After determining both parameters of the formula, sludge tank capacity of each ship can be calculated.

Table.4.1. Sludge tank capacity compilation

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
AEGEAN EXPRESS	171	9994	14.2	1182	3.46831	41.3878668	2.153189
ALIDRA	171	16660	14.5	1016	2.91954	68.99358224	3.021443
AMALTHEA	171	40044	20.5	3726	7.573171	165.8330737	18.83823
ANNA-S	171	21490	15.5	1566	4.209677	88.99592331	5.619662
ARICA BRIDGE	175	21735	21.9	3378	6.426941	92.1160444	8.880365
AS CONSTANTINA	175	20930	11.1	2411	9.0503	88.70433905	12.04201
AS SAVONIA	171	16660	11.2	1016	3.779762	68.99358224	3.91169
BAHAMIAN EXPRESS	171	16660	9.5	1016	4.45614	68.99358224	4.611676
BALLENITA	175	20930	18.8	1566	3.470745	88.70433905	4.618052

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
BEETHOVEN	175	20930	14	1566	4.660714	88.70433905	6.201384
BOMAR FULGENT	171	28773	12.6	1063	3.515212	119.1568032	6.282921
BOMAR SPRING	175	22890	17.5	1063	2.530952	97.0110999	3.682957
BOX EXPRESS	171	13080	14.8	2411	6.787725	54.16783047	5.515145
BOX VOYAGER	171	31640	15.7	2261	6.000531	131.0298285	11.79373
BUXHANSA	171	17940	16.6	2411	6.051707	74.29440969	6.74412
CALIFORNIA TRADER	168.5	16080	14.2	2261	6.63439	65.61808274	6.530039
CAPE MORETON	175	21770	14.2	2411	7.074531	92.26437941	9.790908
CHILOE ISLAND	171	25270	11.4	1063	3.885234	104.6499294	6.098842
CHITTAGONG	171	21735	13	2411	7.727564	90.01053481	10.43343
CIMBRIA	171	25270	18.9	2924	6.446208	104.6499294	10.11893
COSCO ADEN	171	36480	15.3	2261	6.157407	151.0735822	13.95332
COSCO ASHDOD	171	36480	13.6	2247	6.884191	151.0735822	15.60029
COSCO COLOMBO	171	36480	16.6	2261	5.675201	151.0735822	12.86059
COSCO FOS	171	36480	14.4	2261	6.542245	151.0735822	14.82541
COSCO HAIFA	171	36480	14.2	2976	8.732394	151.0735822	19.78851
COSCO IZMIR	171	36480	16.8	2976	7.380952	151.0735822	16.726
COSCO SANTOS	171	36480	15.4	2976	8.051948	151.0735822	18.24655
COSCO SAO PAULO	171	36480	11.9	2976	10.42017	151.0735822	23.61318

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
COSCO WELLINGTON	171	36480	14	2976	8.857143	151.0735822	20.0712
COUGAR	171	10590	11.2	1182	4.397321	43.85606458	2.892738
CPO NORFOLK	171	34000	12.4	2261	7.597446	140.8032291	16.04617
CSCL KINGSTON	175	22890	12.1	1016	3.498623	97.0110999	5.091078
CSCL MANZANILLO	171	21660	18.1	2247	5.172652	89.69993946	6.959798
CSCL MONTEVIDEO	171	21660	14.7	2247	6.369048	89.69993946	8.569548
CSCL SAN JOSE	171	21660	11.7	2261	8.051994	89.69993946	10.83395
CSCL SANTIAGO	171	21660	17.4	2247	5.380747	89.69993946	7.23979
CSCL SAO PAULO	171	21358	12.6	2247	7.430556	88.44927548	9.858409
CUCKOO HUNTER	171	36480	12.9	2261	7.302972	151.0735822	16.54929
DAHLIA	171	25279	10.8	1063	4.10108	104.6872008	6.439959
DEVA	171	36480	13.1	2261	7.191476	151.0735822	16.29663
E.R MARTINIQUE	171	25279	11.5	2411	8.735507	104.6872008	13.71744
ELLA	175	22890	17.5	2976	7.085714	97.0110999	10.31089
EM ANDROS	175	22890	17.5	2411	5.740476	97.0110999	8.353349
EURO MAX	175	22890	11.2	2280	8.482143	97.0110999	12.34293
EVER ABLE	171	10914	15.4	1063	2.876082	45.19783653	1.94989
EVER ALLY	171	10914	13	1063	3.407051	45.19783653	2.30987
EVER APEX	171	10914	18.9	1063	2.343474	45.19783653	1.5888

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
EVER BLISS		-	12.3	2411	8.167344	#VALUE!	#VALUE!
FRISIA NUERNBERG	171	18080	14.4	2924	8.460648	74.87418769	9.502262
FRISIA ROTTERDAM	175	22890	12.4	1566	5.262097	97.0110999	7.657227
GH LESTE	171	31640	15.7	1063	2.821125	131.0298285	5.544773
GH ZONDA	171	31920	17.3	2280	5.491329	132.1893845	10.88843
GUAYAQUIL BRIDGE	171	21660	11.9	1566	5.483193	89.69993946	7.377632
GUENTHER SCHULTE	171	31920	16	1063	2.768229	132.1893845	5.488958
HAI LIAN	175	17200	11.1	2976	11.17117	72.89606458	12.21502
HAMMONIA BEROLINA	171	21660	17.2	1566	3.793605	89.69993946	5.104292
HANSA ROTENBURG	171	16660	11.6	1566	5.625	68.99358224	5.821334
HAYLING ISLAND	171	25279	15.6	1063	2.839209	104.6872008	4.458433
HS CHOPIN	171	32490	14	1063	3.16369	134.5499092	6.385114
HS ONORE	171	28880	14	1063	3.16369	119.5999193	5.675657
IBN AL ABBAR	171	10590	14.1	2411	7.124704	43.85606458	4.686923
INTEGRA		-	11.5	2924	10.5942	#VALUE!	#VALUE!
IRENES RELIANCE	171	25279	16.2	1063	2.734053	104.6872008	4.293306
JPO VELA	171	36480	17.1	3032	7.387914	151.0735822	16.74178
KOTA JAYA	170	13755	12.5	1016	3.386667	56.63007064	2.876808
KOTA JUTA	170	13755	11.2	1016	3.779762	56.63007064	3.210723

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Aver age Spee d*	Miles	Days Spent	Daily Fuel Oil Consum ption (m3)	Sludge Tank (m^3)
KOTA NABIL	171	16660	14.1	2261	6.681 442	68.99358 224	6.9146 49
KOTA NAGA	171	16660	14.4	2261	6.542 245	68.99358 224	6.7705 94
KOTA NASTRAT	171	16660	14.9	2261	6.322 707	68.99358 224	6.5433 93
KOTA NIPAH	171	16660	17.8	2261	5.292 603	68.99358 224	5.4773 35
KOTA RANCAK		6150	16.1	1016	2.629 4	0	0
KOTA TENAGA	178	6960	15.5	1016	2.731 183	30.00314 834	1.2291 61
KOTA WARIS	170	10592	13.3	1016	3.182 957	43.60783 047	2.0820 28
KYAUK PHYU STAR	170	13755	11.1	1016	3.813 814	56.63007 064	3.2396 48
KYOTO TOWER	171	16660	17.5	2411	5.740 476	68.99358 224	5.9408 4
LAKONIA	171	25279	16.3	2924	7.474 438	104.6872 008	11.737 17
LEO PERDANA	175	22890	15.4	2411	6.523 268	97.01109 99	9.4924 42
LOUDS ISLAND	175	22890	10	2411	10.04 583	97.01109 99	14.618 36
LYDIA	175	22890	13.5	3818	11.78 395	97.01109 99	17.147 61
MAERSK JALAN	171	25279	12.6	2280	7.539 683	104.6872 008	11.839 62
MARIA SCHULTE	171	31920	15.4	2261	6.117 424	132.1893 845	12.129 88
MARIA-KATHARINA S	171	31640	11.4	1566	5.723 684	131.0298 285	11.249 6
MERATUS TOMINI	175	22890	13.6	2924	8.958 333	97.01109 99	13.035 87
MERKUR TIDE	171	15995	14.6	1016	2.899 543	66.23963 673	2.8809 71
MILLENIUM BRIGHT	171	15820	16.5	1236	3.121 212	65.51491 423	3.0672 89

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
MIYUNHE	171	10590	14.7	1016	2.879819	43.85606458	1.894463
MOROTAI	178	5669	13.1	1016	3.231552	24.43790918	1.184586
MS EAGLE	171	25279	12.7	1063	3.487533	104.6872008	5.476501
MS HAWK			11.5	1063	3.851449	0	0
MSC CARLA 3	171	24300	17.9	1016	2.364991	100.6328961	3.569938
MSC GIANNA	171	28880	16.2	1016	2.613169	119.5999193	4.688022
MSC GIORGIA	175	25850	11	1016	3.848485	109.556004	6.324369
MSC IMMA	171	28880	13.3	1016	3.182957	119.5999193	5.710222
MSC LUCIA	172	16350	13.8	1016	3.067633	68.10575177	3.133852
MSC REUNION	171	16660	13.8	1016	3.067633	68.99358224	3.174705
MV CIRCULAR QUAY	171	28834	17.7	2261	5.322505	119.4094208	9.533358
NAJADE	175	22890	18.7	2411	5.372103	97.0110999	7.817305
NAVIOS TEMPO	171	36480	14.7	2278	6.456916	151.0735822	14.63204
NAVIOS SPRING	171	36480	16	1063	2.768229	151.0735822	6.273094
NORDCLAIRE	171	14280	15.2	2411	6.609101	59.13735621	5.862671
NORDWOGE	175	26160	11.6	2411	8.660201	110.8698285	14.40233
NORTHERN DEFENDER	171	31920	11.5	1063	3.851449	132.1893845	7.636811
NORTHERN DEMOCRAT	171	31920	13.2	1063	3.355429	132.1893845	6.653282
NORTHERN DIAMOND	171	31920	11.4	1063	3.885234	132.1893845	7.7038

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
NORTHERN VIVACITY	175	22890	11.1	1416	5.315315	97.0110999	7.734669
OLIVIA	175	22890	16.8	2411	5.979663	97.0110999	8.701405
OLYMPIA	171	13080	12.8	2411	7.848307	54.16783047	6.376887
OTTO	175	25850	16	1016	2.645833	109.556004	4.348004
PHILIPPA SCHULTE	171	31920	11.4	2261	8.263889	132.1893845	16.38598
PONA	169	21770	15.6	2924	7.809829	89.10102926	10.43796
PORT ADELAIDE	175	21735	13.6	3347	10.25429	92.1160444	14.16877
POSEN	169	21770	14.9	1063	2.972595	89.10102926	3.972919
PRINCESS OF LUCK	171	12240	10.6	2411	9.477201	50.68916246	7.205871
PROTOSTAR N	169	21770	16.1	2411	6.239648	89.10102926	8.339386
QINGDAO		18000	16.6	2924	7.339357	0	0
QUEEN OF LUCK	171	13125	13.3	1236	3.87218	54.35418769	3.157038
RUBINA SCHULTE	171	25270	16.3	1063	2.71728	104.6499294	4.265448
SARAH SCHULTE	171	25270	17.5	1063	2.530952	104.6499294	3.97296
SEASPAN FRASER	171	36480	15.3	2261	6.157407	151.0735822	13.95332
SEASPAN SANTOS	171	36480	13.8	2261	6.826691	151.0735822	15.46999
SEASPAN VANCOUVER	171	36480	20.1	3300	6.840796	151.0735822	15.50195
SELATAN DAMAI		3310	10.4	1016	4.070513	0	0
SFL AVON	171	16660	11.4	1566	5.723684	68.99358224	5.923462

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
SINAR BITUNG	171	12640	17.2	1236	2.994186	52.34567104	2.35099
SINAR SABANG	171	16660	13.9	1016	3.045564	68.99358224	3.151865
SINAR SUMBA	171	16660	18.5	1236	2.783784	68.99358224	2.880948
SITC SURABAYA	175	22890	14.8	2924	8.231982	97.0110999	11.9789
SONGA HAYDN	171	28834	15.1	1063	2.933223	119.4094208	5.253817
SOUL OF LUCK	171	12240	11.1	1182	4.436937	50.68916246	3.373569
SPECTRUM N	171	21490	11.3	1566	5.774336	88.99592331	7.708386
ST ISLAND	175	21771	16.5	2411	6.088384	92.26861756	8.426501
ST. MARY	171	15798	15.1	1016	2.803532	65.42380626	2.751266
STAR OF LUCK	171	12438	14.4	1236	3.576389	51.50913421	2.76325
TR ARAMIS	168.5	16080	14.2	2924	8.579812	65.61808274	8.444862
TR ATHOS		-	11.2	3347	12.45164	#VALUE!	#VALUE!
TS TAICHUNG		18000	12.6	1416	4.68254	0	0
UNI AMPLE	171	10914	15.1	1063	2.933223	45.19783653	1.98863
UNI FORTUNA	171	31920	13.4	1063	3.305348	132.1893845	6.553979
URU BHUM	169	20580	16.6	2411	6.051707	84.23055499	7.646079
VALERIE SCHULTE	171	25270	15.4	1063	2.876082	104.6499294	4.514727
VENETIA	171	40044	15.8	2261	5.962553	165.8330737	14.83183
VICTORIA SCHULTE	175	22890	17.8	1063	2.488296	97.0110999	3.620885

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Average Speed*	Miles	Days Spent	Daily Fuel Oil Consumption (m3)	Sludge Tank (m^3)
WAN HAI 212	171	11060	11.2	2411	8.969494	45.80246216	6.162374
WAN HAI 216	171	11060	15.8	2411	6.358122	45.80246216	4.368265
WAN HAI 231	171	16660	15.2	2411	6.609101	68.99358224	6.839783
WAN HAI 271	171	16660	18.4	2411	5.459692	68.99358224	5.650256
WAN HAI 273	171	15820	17.4	2411	5.773467	65.51491423	5.673723
WAN HAI 281	171	10590	15.1	2411	6.65287	43.85606458	4.37653
WARNOW CHIEF	171	11120	12.9	1016	3.281654	46.05093845	2.266849
WELLINGTON STRAIT	171	16660	18.2	2924	6.694139	68.99358224	6.92779

VI.1.3. Determining Adequate Capacity of Sludge Treatment Receiver

The adequate capacity of sludge receiver can be determined by the largest compilation volume of sludge tanks of the ship doing its loading-unloading process at the terminal per day. From the data above and according to ship's arrival record, these points can be achieved:

- Average compiled volume per day : 17.15 m^3.
- Maximum compiled volume per day : 52.7 m^3.
- Minimum compiled volume per day : 1.895 m^3.
- Largest sludge tank volume : 23.6 m^3 (Csc. Sao Paulo)

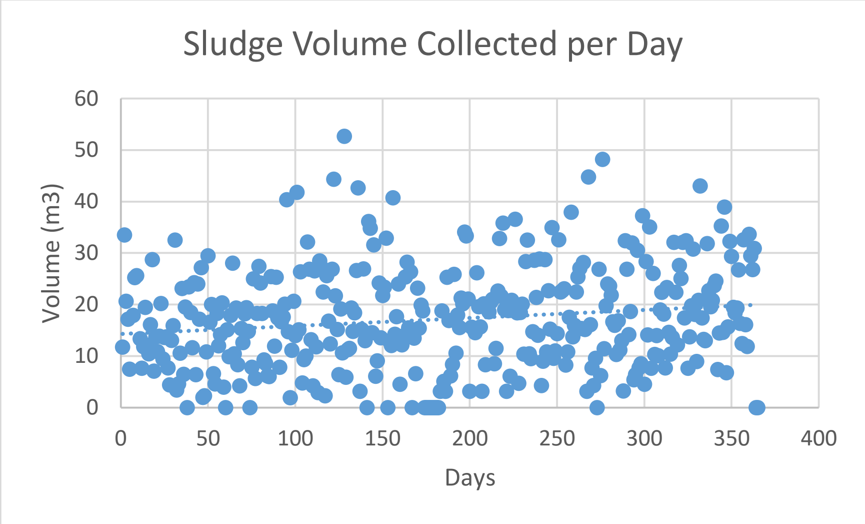


Fig.4.3. Assumed sludge volume discharged per day

IV.2. Determining Adequate Capacity of Oily Bilge Receiver

The capacity of adequate oily bilge receiver should be determined before designing the complete discharge water treatment system. However, the oily bilge is frequently being treated onboard ship before discharging and it has large volume. The oily bilge receiver can be studied further after determining which the average, maximum and minimum oily bilge volume discharged per day.

IV.2.1. Determining Oily Bilge Holding Tank of Each Ship

The oily bilge holding tank capacity of each ship can be determined by the following formula:

Table.4.2. Recommended capacity of oily bilge water holding tank

Main Engine Rating (kW)	Capacity (m^3)
Up to 1,000	4
Above 1,000 up to 20,000	P/250
Above 20,000	40 + P/500

(Source: IMO, 2008)

According to the recommended capacity of oily bilge water holding tank above, the capacity of oily bilge holding tank of each ship then can be determined.

Table.4.3. Oily bilge holding tank capacity compilation

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Daily Fuel Oil Consumption (m3)	Oily Bilge Holding Tank (m^3)
AEGEAN EXPRESS	171	9994	41.3878668	39.976
ALIDRA	171	16660	68.99358224	66.64
AMALTHEA	171	40044	165.8330737	120.088
ANNA-S	171	21490	88.99592331	82.98
ARICA BRIDGE	175	21735	92.1160444	83.47
AS CONSTANTINA	175	20930	88.70433905	81.86
AS SAVONIA	171	16660	68.99358224	66.64
BAHAMIAN EXPRESS	171	16660	68.99358224	66.64
BALLENITA	175	20930	88.70433905	81.86
BEETHOVEN	175	20930	88.70433905	81.86
BOMAR FULGENT	171	28773	119.1568032	97.564
BOMAR SPRING	175	22890	97.0110999	85.78
BOX EXPRESS	171	13080	54.16783047	52.32
BOX VOYAGER	171	31640	131.0298285	103.28
BUXHANSA	171	17940	74.29440969	71.76
CALIFORNIA TRADER	168.5	16080	65.61808274	64.32
CAPE MORETON	175	21770	92.26437941	83.54
CHILOE ISLAND	171	25270	104.6499294	90.54
CHITTAGONG	171	21735	90.01053481	83.47
CIMBRIA	171	25270	104.6499294	90.54
COSCO ADEN	171	36480	151.0735822	112.96
COSCO ASHDOD	171	36480	151.0735822	112.96
COSCO COLOMBO	171	36480	151.0735822	112.96
COSCO FOS	171	36480	151.0735822	112.96
COSCO HAIFA	171	36480	151.0735822	112.96
COSCO IZMIR	171	36480	151.0735822	112.96
COSCO SANTOS	171	36480	151.0735822	112.96
COSCO SAO PAULO	171	36480	151.0735822	112.96
COSCO WELLINGTON	171	36480	151.0735822	112.96
COUGAR	171	10590	43.85606458	42.36
CPO NORFOLK	171	34000	140.8032291	108
CSCL KINGSTON	175	22890	97.0110999	85.78
CSCL MANZANILLO	171	21660	89.69993946	83.32
CSCL MONTEVIDEO	171	21660	89.69993946	83.32

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Daily Fuel Oil Consumption (m3)	Oily Bilge Holding Tank (m^3)
CSCL SAN JOSE	171	21660	89.69993946	83.32
CSCL SANTIAGO	171	21660	89.69993946	83.32
CSCL SAO PAULO	171	21358	88.44927548	82.716
CUCKOO HUNTER	171	36480	151.0735822	112.96
DAHLIA	171	25279	104.6872008	90.558
DEVA	171	36480	151.0735822	112.96
E.R MARTINIQUE	171	25279	104.6872008	90.558
ELLA	175	22890	97.0110999	85.78
EM ANDROS	175	22890	97.0110999	85.78
EURO MAX	175	22890	97.0110999	85.78
EVER ABLE	171	10914	45.19783653	43.656
EVER ALLY	171	10914	45.19783653	43.656
EVER APEX	171	10914	45.19783653	43.656
EVER BLISS	171	28880	119.5999193	97.76
FRISIA NUERNBERG	171	18080	74.87418769	72.32
FRISIA ROTTERDAM	175	22890	97.0110999	85.78
GH LESTE	171	31640	131.0298285	103.28
GH ZONDA	171	31920	132.1893845	103.84
GUAYAQUIL BRIDGE	171	21660	89.69993946	83.32
GUENTHER SCHULTE	171	31920	132.1893845	103.84
HAI LIAN	175	17200	72.89606458	68.8
HAMMONIA BEROLINA	171	21660	89.69993946	83.32
HANSA ROTENBURG	171	16660	68.99358224	66.64
HAYLING ISLAND	171	25279	104.6872008	90.558
HS CHOPIN	171	32490	134.5499092	104.98
HS ONORE	171	28880	119.5999193	97.76
IBN AL ABBAR	171	10590	43.85606458	42.36
INTEGRA	171	16660	68.99358224	66.64
IRENES RELIANCE	171	25279	104.6872008	90.558
JPO VELA	171	36480	151.0735822	112.96
KOTA JAYA	170	13755	56.63007064	55.02
KOTA JUTA	170	13755	56.63007064	55.02
KOTA NABIL	171	16660	68.99358224	66.64
KOTA NAGA	171	16660	68.99358224	66.64
KOTA NASTRAT	171	16660	68.99358224	66.64

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Daily Fuel Oil Consumption (m3)	Oily Bilge Holding Tank (m^3)
KOTA NIPAH	171	16660	68.99358224	66.64
KOTA RANCAK		6150	0	24.6
KOTA TENAGA	178	6960	30.00314834	27.84
KOTA WARIS	170	10592	43.60783047	42.368
KYAUK PHYU STAR	170	13755	56.63007064	55.02
KYOTO TOWER	171	16660	68.99358224	66.64
LAKONIA	171	25279	104.6872008	90.558
LEO PERDANA	175	22890	97.0110999	85.78
LOUDS ISLAND	175	22890	97.0110999	85.78
LYDIA	175	22890	97.0110999	85.78
MAERSK JALAN	171	25279	104.6872008	90.558
MARIA SCHULTE	171	31920	132.1893845	103.84
MARIA-KATHARINA S	171	31640	131.0298285	103.28
MERATUS TOMINI	175	22890	97.0110999	85.78
MERKUR TIDE	171	15995	66.23963673	63.98
MILLENIUM BRIGHT	171	15820	65.51491423	63.28
MIYUNHE	171	10590	43.85606458	42.36
MOROTAI	178	5669	24.43790918	22.676
MS EAGLE	171	25279	104.6872008	90.558
MS HAWK			0	90.558
MSC CARLA 3	171	24300	100.6328961	88.6
MSC GIANNA	171	28880	119.5999193	97.76
MSC GIORGIA	175	25850	109.556004	91.7
MSC IMMA	171	28880	119.5999193	97.76
MSC LUCIA	172	16350	68.10575177	91.7
MSC REUNION	171	16660	68.99358224	66.64
MV CIRCULAR QUAY	171	28834	119.4094208	97.668
NAJADE	175	22890	97.0110999	85.78
NAVIOS TEMPO	171	36480	151.0735822	112.96
NAVIOS SPRING	171	36480	151.0735822	112.96
NORDCLAIRE	171	14280	59.13735621	57.12
NORDWOGE	175	26160	110.8698285	92.32
NORTHERN DEFENDER	171	31920	132.1893845	103.84
NORTHERN DEMOCRAT	171	31920	132.1893845	103.84
NORTHERN DIAMOND	171	31920	132.1893845	103.84

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Daily Fuel Oil Consumption (m3)	Oily Bilge Holding Tank (m^3)
NORTHERN VIVACITY	175	22890	97.0110999	85.78
OLIVIA	175	22890	97.0110999	85.78
OLYMPIA	171	13080	54.16783047	52.32
OTTO	175	25850	109.556004	91.7
PHILIPPA SCHULTE	171	31920	132.1893845	103.84
PONA	169	21770	89.10102926	83.54
PORT ADELAIDE	175	21735	92.1160444	83.47
POSEN	169	21770	89.10102926	83.54
PRINCESS OF LUCK	171	12240	50.68916246	48.96
PROTOSTAR N	169	21770	89.10102926	83.54
QINGDAO		18000	0	72
QUEEN OF LUCK	171	13125	54.35418769	52.5
RUBINA SCHULTE	171	25270	104.6499294	90.54
SARAH SCHULTE	171	25270	104.6499294	90.54
SEASPAN FRASER	171	36480	151.0735822	112.96
SEASPAN SANTOS	171	36480	151.0735822	112.96
SEASPAN VANCOUVER	171	36480	151.0735822	112.96
SELATAN DAMAI		3310	0	13.24
SFL AVON	171	16660	68.99358224	66.64
SINAR BITUNG	171	12640	52.34567104	50.56
SINAR SABANG	171	16660	68.99358224	66.64
SINAR SUMBA	171	16660	68.99358224	66.64
SITC SURABAYA	175	22890	97.0110999	85.78
SONGA HAYDN	171	28834	119.4094208	97.668
SOUL OF LUCK	171	12240	50.68916246	48.96
SPECTRUM N	171	21490	88.99592331	82.98
ST ISLAND	175	21771	92.26861756	83.542
ST. MARY	171	15798	65.42380626	63.192
STAR OF LUCK	171	12438	51.50913421	49.752
TR ARAMIS	168.5	16080	65.61808274	64.32
TR ATHOS		-	#VALUE!	64.32
TS TAICHUNG		18000	0	72
UNI AMPLE	171	10914	45.19783653	43.656
UNI FORTUNA	171	31920	132.1893845	103.84
URU BHUM	169	20580	84.23055499	81.16

SHIP'S NAME	SFOC (g/kWh)	Engine Power (kW)	Daily Fuel Oil Consumption (m3)	Oily Bilge Holding Tank (m^3)
VALERIE SCHULTE	171	25270	104.6499294	90.54
VENETIA	171	40044	165.8330737	120.088
VICTORIA SCHULTE	175	22890	97.0110999	85.78
WAN HAI 212	171	11060	45.80246216	44.24
WAN HAI 216	171	11060	45.80246216	44.24
WAN HAI 231	171	16660	68.99358224	66.64
WAN HAI 271	171	16660	68.99358224	66.64
WAN HAI 273	171	15820	65.51491423	63.28
WAN HAI 281	171	10590	43.85606458	42.36
WARNOW CHIEF	171	11120	46.05093845	44.48
WELLINGTON STRAIT	171	16660	68.99358224	66.64

From the data above and ship arrival record, the maximum, minimum and average oily bilge water volume can be determined.

- Average oily bilge water volume per day : 201.65 m^3
- Maximum oily bilge water volume per day : 442 m^2
- Minimum oily bilge water volume per day : 42.36 m^2

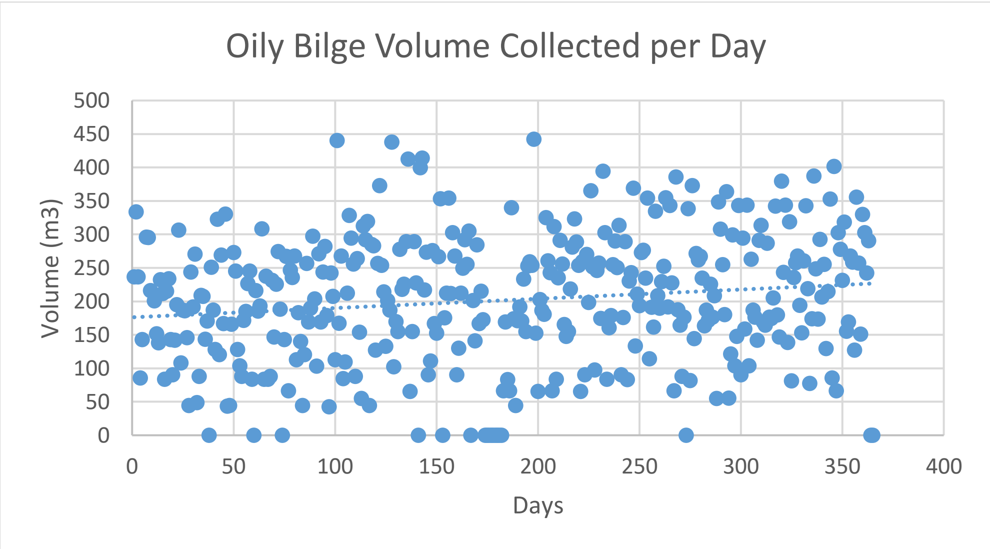


Fig.4.4. Assumed oily bilge volume collected per day

IV.3. Determining Adequate Capacity of Black Treatment Receiver

The adequate capacity of blackwater treatment receiver can be determined by the volume of blackwater holding tank of each ship calculated between the time of right before entering Indonesian water until the ship has arrived safely at the port and is ready to discharge the blackwater. For this arrangement, the period of voyage is estimated to be 3 days. The blackwater holding tank capacity can be calculated by the following formula:

$$V\ (m^3) = \frac{3\ days\ x\ 20kg\ x\ number\ of\ crew}{1.025}$$

According to the ship arrival data and local minimum safe manning regulations, 4 ships out of 150 are manned by 20 crews and the rest are manned by 21 crews. Therefore, there are only small differences between the 21-crews manned and 20-crews manned ships, resulting in the average blackwater holding tank capacity of 1.2 m^3. Based on the ship arrival data, the most frequent number of ship arriving in one day is 5 ships. Thus:

- Average blackwater volume discharged per day : 3.37 m^3
- Maximum blackwater volume discharged per day : 6.15 m^3
- Minimum blackwater volume discharges per day : 1.23 m^3

IV.4. Determining Adequate Capacity of Greywater Treatment

The adequate capacity of greywater treatment receiver can be determined by the volume of greywater holding tank of each ship calculated between the time of right before entering Indonesian water until the ship has arrived safely at port and is ready to discharge the greywater. For this arrangement, the period of voyage is estimated to be 3 days. The greywater holding tank capacity can be calculated by the following formula:

$$V\ (m^3) = \frac{3\ days\ x\ 55kg\ x\ number\ of\ crew}{1.025}$$

The average greywater holding tank capacity is 3.38 m^3. Based on the ship arrival data, the most frequent number of ship arriving in one day is 5 ship. Thus:

- Average greywater volume discharged per day : 9.27 m^3
- Maximum greywater volume discharged per day : 16.9 m^3
- Minimum greywater volume discharged per day : 3.38 m^3

IV.5. Design of Discharge Water Treatment Plant

The design of compact and fixed discharge water treatment plant has to be limited by several conditions and requirements:

1. The free space provided by TPS is located 691.71 meters apart from the nearest berth and 2,240 meters apart from the farthest berth. Thus, a transportation means will be necessary, either using trucks or pipelines.

Fig.4.5. Free space provided by the terminal
(Source: Google Maps)

2. The free space is 416 meters length and 244 meters wide, resulting in area of 101,504 m^2.

IV.5.1. Chosen Design of Sludge Treatment

The sludge and oily bilge will be handled by centrifugation method, whereas the water content in the oily bilge will be first eliminated. If a ship wishes to dispose its oily bilge having oil content exceeding 15 ppm then a treatment for oily bilge should be provided.

Centrifugation method using centrifuges to separate fluids based by their densities whether it is water, solids, oil and pasty mixtures. First, sludge is inserted into pre-treatment tank, which is purposed to reduce its viscosity by adding solvents, demulsifying agent and steam for heating. Once the viscosity of the sludge is reduced, the less viscous sludge is pumped into the centrifuge. The centrifuge then separates oily mixtures, oily wastewater and waste solids. The oil phase then purified further using gravimetric separator to produce recovered oil and separate solids. The wastewater then goes into wastewater treatment unit while waste solids will be sent to landfill (Islam, 2015).

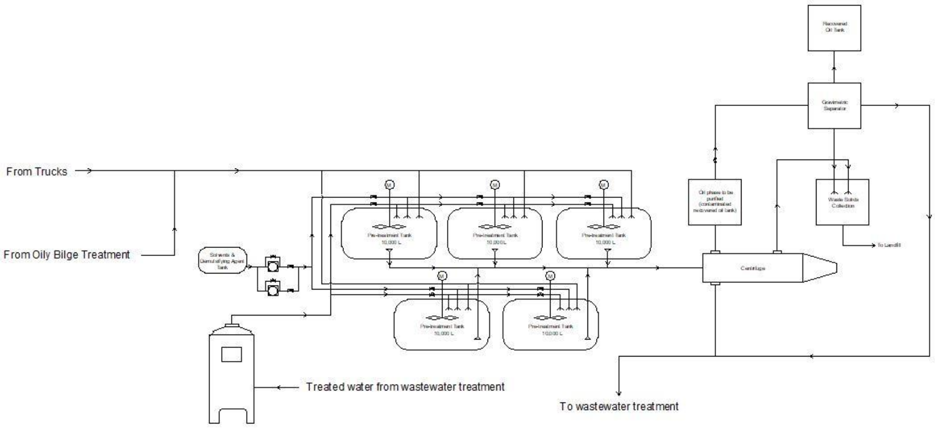


Fig.4.6. Schematic flow of centrifugation method of oily sludge treatment

IV.5.2. Chosen Design of Oily Bilge Treatment

The chosen design of oily bilge treatment is using ulrafiltration. The ultrafiltration method of treatment produces a water phase which is generally of acceptable quality for direct sewer discharge into the sea, and an oil phase that can be incinerated. Reverse osmosis (RO) and activated carbon treatment will permit reuse of the treated water as process water. The maximum attainable oil concentration ranges from 25 to 65% oil.

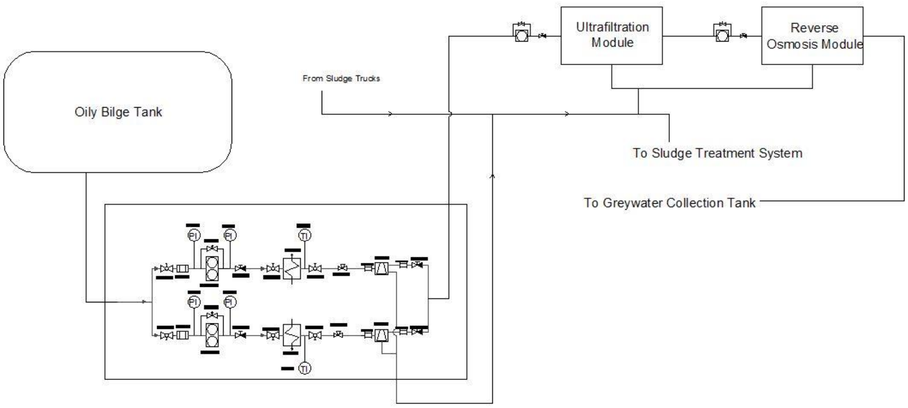


Fig.4.7. System design of oily bilge water treatment

IV.5.3. Chosen Design of Blackwater Treatment

According to a blackwater treatment research conducted on Secovlje Saltpans Natural Park, Slovenia, as remote tourist facilities, a simple design using peat filters, compost reactor, biofilters and evaporation module can be used to minimize the discharge and reuse the solid fraction as additional P (phosphorous) for agricultural purpose (Oarga-Mulec, Jenssen, Klemencic, Ursic, & Bulc, 2017).

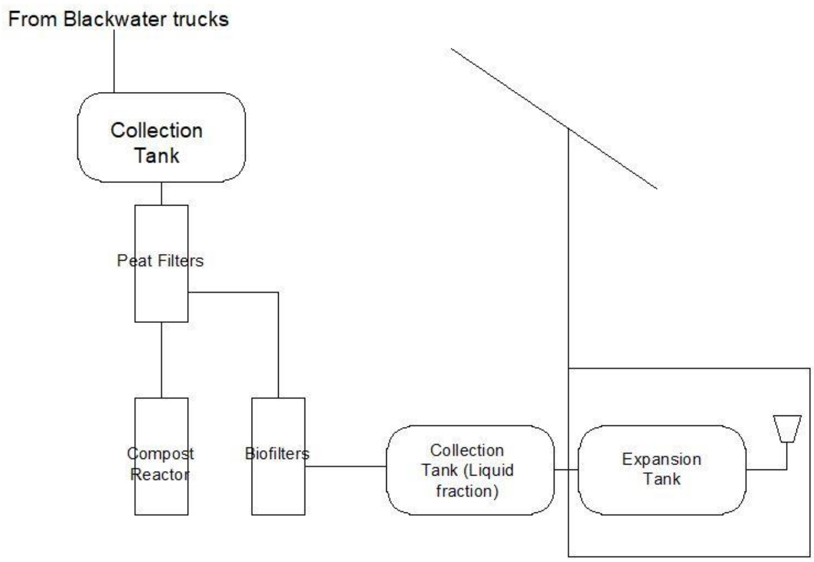


Fig.4.8. System design for blackwater treatment

IV.5.4. Chosen Design of Greywater Treatment

The chosen design of greywater is using membrane bio-reactor (MBR) since MBR is more economically reliable, compact and produce better treated water quality. The specific energy consumption of MBR based IISc STP (Indian Institute of Science Sewage Treatment Plant) is higher than conventional CAS based STPs (Ashok, Kumar, & Bhalla, 2018). The MBR for domestic sewage wastewater is available commercially worldwide in compact design (containerized).

Based on Fig.4.9. below, technically, the MAK Water MBR Sewage Treatment Plant starts from balance tank, followed by a filter called micro screen, anoxic zone with mixer, aerobic zone, UF (ultrafiltration) and treatet effluent tank. The product of this treatment plant is reusable fresh water and dry sludge.

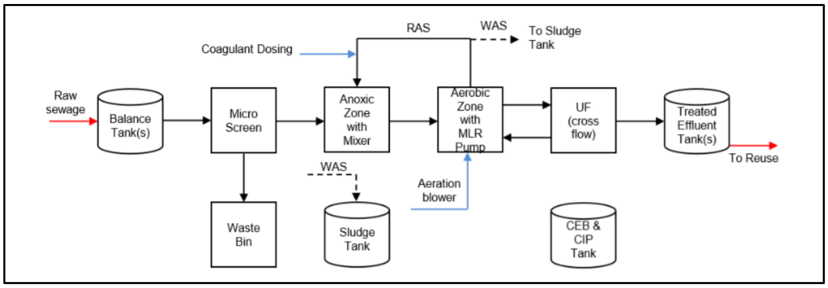


Fig.4.9. Process steps of MAK Water MBR Sewage Treatment Plant
(Image source: MAK Water Product Overview)

IV.6. Economic Analysis on Port-Based Discharge Water Treatment Plant

The economic analysis of port-based discharge water treatment is divided into three categories; the installation cost by the means of transportation, water treatment plant's main equipment cost and payback period (PBP) of the plant. Some assumptions are made in absence of actual installation cost data.

IV.6.1. Transportation

The transfer of discharge water from ship to shore is conducted by the vessel to the receivers. In this case, the oily sludge and blackwater are received by trucks while the oily bilge and greywater are delivered to the discharge water treatment facilities by pipelines. The total transportation installation cost **is IDR 5,856,040,711.2** or around **USD 415,675.80** with detailed estimation as follows:

Sludge

Table.4.4. Sludge transportation cost

No.	Equipment Name	Note	Price
1.	2 x RAC Vacuum-Jetting-Flushing Tank Truck	Tank volume: @20,000L	USD 78,000
	Shipping cost	Japan – Ind.	USD 1,452
	Total cost & freight		USD 1,119,319,776
	Import duty	10%	IDR 111,931,978
	VAT (Value Added Tax)	10%	IDR 123,125,175
	Income Tax	2.5%	IDR 30,781,294
	Total Tax		IDR 265,838,447
Total Payable			**IDR 1,385,158,223**

Blackwater

Table.4.5. Blackwater transportation cost

No.	Equipment Name	Note	Price
1.	ShinMaywa Clean Cuum GV11 – W201C	Tank volume: 10,500L	USD 45,000
	Shipping cost	Japan – Ind.	USD 1,452
	Total cost & freight		IDR 654,415,776
	Import duty	10%	IDR 65,441,578
	VAT (Value Added Tax)	10%	IDR 71,985,735
	Income Tax	2.5%	IDR 17,996,434
	Total Tax		IDR 155,423,747
Total Payable			**IDR 809,839,523**

Oily Bilge

Table.4.6. Oily bilge transportation cost

No.	Equipment Name	Note	Price
1.	Galvanized pipe	2,240 m	IDR 1,780,800,000
2.	Booster pump	2 sets	IDR 19,723,200
	Freight cost		IDR 20,455776
	Total cost & freight		IDR 40,178,976
	Import duty	10%	IDR 4,017,898
	VAT	10%	IDR 4,419,687.4
	Income tax	2.5%	IDR 9,542,507
	Total pump payable		IDR 49,721,483
TOTAL PAYABLE			**IDR 1,830,521,483**

Greywater

Table.4.7. Greywater transportation cost

No.	Equipment Name	Note	Price
1.	Pipe	2,240 m	IDR 1,780,800,000
2.	Booster pump	2 sets	IDR 19,723,200
	Freight cost		IDR 20,455776
	Total cost & freight		IDR 40,178,976
	Import duty	10%	IDR 4,017,898
	VAT	10%	IDR 4,419,687.4
	Income tax	2.5%	IDR 9,542,507
	Total pump payable		IDR 49,721,483
TOTAL PAYABLE			**IDR 1,830,521,483**

IV.6.2. Overall Design Main Equipment Cost

The discharge water treatment plant consists of several main equipment which is needed to be supplied, whether it is being built on site or directly installed after imported. The total main equipment cost is resulting around **IDR 16,631,046,165.** The list of main equipment needed by the discharge water treatment plant is shown on the table below.

Table.4.8. Overall system main equipment cost

No.	Equipment Name	Price
Sludge Treatment		
1.	Pre-treatment tank with mixer	5 x IDR 1,608,187,464
2.	Demulsifying agent tank	IDR 1,608,187,464
3.	Demulsifying agent dosing pump	IDR 14,088,000
4.	Boiler	IDR 70,158,240
5.	Incinerator	IDR 33,811,200
6.	Centrifuge	IDR 42,264,000
7.	Contaminated recovered oil tank	IDR 28,176,000
8.	Waste solid collection tank	IDR 28,176,000
9.	Gravimetric separator	IDR 56,352,000
10.	Recovered oil tank	IDR 28,176,000
Greywater Treatment		
1.	Compact MBR	IDR 2,113,200,000
2.	Treated effluent tank	IDR 70,440,000
3.	Greywater collection tank	IDR 11,270,400
Oily Bilge		
1.	Oily bilge holding tank	IDR 704,400,000
2.	Separator	IDR 90,867,600
3.	Ultrafiltration pump	IDR 5,635,200
4.	Ultrafiltration Module	IDR 88,754,400
5.	Reverse osmosis module	IDR 180,326,400
Blackwater		
1.	Collection tank	IDR 28,176,000
2.	Feed pump	IDR 26,767,200
3.	Tank for peat filters	IDR 28,176,000
4.	Tank for compost reactor	IDR 28,176,000
5.	Tank for Biofilter	IDR 28,176,000
6.	Collection Tank (LF)	IDR 28,176,000

7.	Evaporation tank	IDR 28,176,000
8.	Cascade dryer	IDR 16,905,600
9.	Solar Vacuum Collector (SVC)	IDR 11,270,400
Total		**IDR 13,439,219,424**
Estimated freight cost		IDR 9,800
Total payable before tax		IDR 13,439,229,224
Import duty		IDR 1,343,922,922
VAT (Value Added Tax)		IDR 1,478,315,215
Income Tax		IDR 369,578,804
Final Total		**IDR 16,631,046,165**

IV.6.3. Payback Period (PBP)

The chosen method for investment evaluation in this bachelor thesis is payback period (PBP). The payback period analysis is basically aiming to determine how long the period of time of an investment to be paid back in time of break even-point (Giatman, 2006). Period of payback in BEP (break even-point) condition is calculated by following formula:

$$k_{(PBP)} = \sum_{t=0}^{k} CF_t \geq 0$$

where:

k = payback period value

CF_t = cash flow in t^{th} period.

The investment plant using this method is called feasible economically if the value *k* is smaller or equal to n ($k \geq n$), where n is the investment time.

Before determining the value of *k*, the amount of annual benefit has to be analyzed first. To do so, the author use some assumption as listed below:

1. The discharge water management fee is charged to the shipowner based on the ship's gross tonnage. The cost for the discharge water management is adopted from Patras Port Authority regarding fee & rates for waste reception facilities. The annual gross revenue from the fee is estimated to be **IDR 12,941,480,256**.

Table.4.9. Fee of Waste Reception Facilities

SHIP SIZE	PRODUCT	FEE (€)
Ships up to 1,000 GT	200x1	200
Ships from 1,001 to 5,000 GT	200x2	400
Ships from 5,001 to 10,000 GT	200x3	600
Ships from 10,001 to 25,000	200x5	1000

SHIP SIZE	PRODUCT	FEE (€)
Ships from 25,001 to 50,000 GT	200x8	1600
Ships larger than 50,000 GT	200x10	2000

(Source: Patras Port Authority, 2014)

2. The installation cost of the plant is estimated to be 50% of total main equipment investment, resulting in total investment of **IDR 33,730,630,314**.
3. The operational cost is divided into two: handling crew salary and technical operational expenditure. The annual salary for 10 handling crews is estimated to be IDR 600,000,000 and technical operational expenditure is estimated to be IDR 3,373,063,031. Total operational cost is estimated to be **IDR 3,973,063,031.**
4. The economic life (*n*) is estimated to be 10 years.

Payback period (PBP) $= \frac{Total\ investment}{(Annual\ gross\ revenue - annual\ operational\ cost)}$

$= \frac{IDR\ 33{,}730{,}630{,}314}{(IDR\ 12{,}941{,}480{,}256 - IDR\ 3{,}973{,}063{,}031)}$

= **4 years.**

CHAPTER V
CONCLUSION & RECOMMENDATIONS

V.1. Conclusions

1. The adequate capacity of sludge receiver can be determined by the largest compilation volume of sludge tanks of the ship doing its loading-unloading process at the terminal per day. The average compiled volume per day is 17.15 m^3, maximum compiled volume per day is 52.7 m^3, minimum compiled volume per day is 1.895 m^3 while the largest sludge tank volume is carried by COSCO SAO PAULO with 23.6 m^3.
2. The adequate capacity of oily bilge water volume receiver can be determined by the maximum oily bilge water received per day 442 m^3. Average oily bilge water volume per day is 201.65 m^3 while the minimum is 42.36 m^3.
3. The adequate capacity of blackwater receiver can determined from its maximum blackwater volume discharged per day which is 6.15 m^3. The average of blackwater volume discharged is 3.37 m^3 while the minimum is 1.23 m^3.
4. The adequate capacity of greywater treatment receiver can be determined by the maximum volume of greywater discharge per day which is 16.9 m^3. The average of greywater volume discharged per day is 9.27 m^3 while the minimum is 3.38 m^3.
5. The design of port-based discharge water treatment is choosing the simplest while combining four treatments on the first step of treatment. Sludge is treated by centrifugation method, oily sludge is treated by ultrafiltration and reverse osmosis, greywater is treated by Membrane Bioreactor (MBR) and blackwater is treated by SSS (Source Separation Sanitation). The overall system design is shown on the Attachment 2.
6. The estimated initial cost for the plant can be reviewed from two categories: transportation initial cost and water treatment plant initial cost. The total transportation (from ship to WTP) initial cost is estimated around IDR 5,856,040,711.2 and the total water treatment plant initial cost is estimated to be around IDR 16,631,046,165 resulting in total of **IDR 22,487,086,876**. The payback period (PBP) of this plant is 4 years.

V.II. Recommendations

1. The pilot design of this port-based discharge water treatment plant is still far from perfect, thus, further research done by more professional field of treating discharge water is highly needed.

2. A simulation of the system is not done, as it is not the research scope for this bachelor thesis. A proper simulation may be needed to find whether the system will work out or not.
3. A comparison between this port-based discharge water treatment plant and another urban wastewater treatment plant is needed and can only be done by environmental engineering professionals, therefore, the author suggests that this bachelor thesis will undergo further research to check out its feasibility.
4. The economic analysis needs to be analyzed further and in more detail, given that the author uses many assumption on this bachelor thesis.

REFERENCES

Ashok, S., Kumar, T., & Bhalla, K. (2018). Integrated Greywater Management Systems: A Design Proposal for Efficient and Decentralised Greywater Sewage Treatment. *25th CIRP Life Cycle Engineering (LCE) Conference* (pp. 609-614). Copenhagen: Elsevier.

Badan Informasi Geospasial. (2015, Januari 15). *Pentingnya Informasi Geospasial untuk Menata Laut Indonesia*. Retrieved from Badan Informasi Geospasial: http://big.go.id/berita-surta/show/pentingnya-informasi-geospasial-untuk-menata-laut-indonesia

Barisci, S., & Turkay, O. (2016). Domestic Greywater Treatment by Electrocoagulation Using Hybrid Electrode Combinations. *Journal of Water Process Engineering 10*, 56-66.

Giatman, M. (2006). *Ekonomi Teknik.* Jakarta: PT RajaGrafindo Persada.

International Chamber of Shipping. (2018, August 4). *International Chamber of Shipping*. Retrieved from Shipping and World Trade: http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade

Islam, B. (2015). Petroleum Sludge, Its Treatment and Disposal: A Review. *International Journal of Chemical Sciences*, 1584-1602.

National Development Planning Agency (BAPPENAS). (2013, July 23). *Brief Perspective on National and International Shipping Network in Indonesia*. Retrieved from UNESCAP: https://www.unescap.org/sites/default/files/0.Indonesia.pdf

Oarga-Mulec, A., Jenssen, P. D., Klemencic, A. K., Ursic, M., & Bulc, T. G. (2017). Zero-Discharge Solution for Blackwater Treatment at Remote Tourist Facilities. *Journal of Cleaner Production*, 798-805.

Patras Port Authority. (2014, October 9). *Patras Port Authority.* Retrieved from Fee & Rates for the Provision of Waste Reception Facilities Patras Port Authority: http://www.patrasport.gr/cms/wp-content/uploads/fees-rates-unscheduled_en.pdf

PT. TPS. (2017). *Data Asset.* Surabaya: PT. TPS.

Tamelander, J., & Riddering, e. a. (2010). *Guidelines for Development of a National Ballast Water Management Strategy.* London: GloBallast Partnership Project Coordination Unit IMO.

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AUTHOR'S BIODATA

The Author's name is Nurkhairana Aryanti Trikurnia and was born in Surabaya, 21 November 1997 as the second child of three from parents Ir. Dwi Aryo Putro and Drs. Widajanti Purnomosari. The Author attended her formal education starting from SDN Padurenan IV Kota Bekasi for elementary level, SMPN 16 Kota Bekasi for junior high level and Sekolah Indonesia Singapura for senior high level. In July 2015, the Author was announced to had passed national written test and recognized as undergraduate student of Department of Marine Engineering (Double Degree Program with Hochschule Wismar Germany), Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember. During her college period, the Author was an active member of Himpunan Mahasiswa Teknik Sistem Perkapalan (Himasiskal) as Innovation Department's Secretary (2016 – 2017), Head Secretary of Marine Engineering Department Graduation Party 114 and Marine Machinery and System Laboratory. The Author did her On the Job Training (internship program) in PT. Dumas Tanjung Perak Shipyard and Indonesia Hydrodynamic Laboratory (IHL) for two months. The Author finished her bachelor degree in 7 semesters.

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ATTACHMENT

This attachment consists of 3 sections:

A. Section A: list of ship, main principal data of ships, estimated ship's discharge water volume per arrival and list of fees of waste handling per ship.
B. Section B: overall drawing of port-based discharge water treatment system.
C. Section C: list of proposed main equipment specification

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ATTACHMENT A

SUMMARY OF DATA COLLECTION & DATA ANALYSIS

Attachment Table A.1. Main principal dimension of ship

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
AEGEAN EXPRESS	9138161	15095	18581	168.8	27.3	8.4	11/10/1997	MAN B&W	7S50MCC	171	9994	18.2
ALIDRA	9202481	17167	21331	168.7	27.2	9.22	4/10/2000	MAN B&W	7S60MCC	171	16660	20
AMALTHEA	9397913	42609	52788	268.8	32.2	12.5	Oct-09	Wartsila	7RT-flex96C	171	40044	24.5
ANNA-S	9383223	26435	34362.8	209	29.8	11.6	3/25/2008	Winterthur Gas & Diesel Ltd.	7RT-flex68-B	171	21490	22
ARICA BRIDGE	9451484	27094	33304	199.9	32.2	11.3	1/29/2010	MAN B&W	7S70MC	175	21735	22.5
AS CONSTANTINA	9308390	27786	37882.7	221.7	29.8	11.4	6/9/2005	MAN B&W	7L70MCC	175	20930	22
AS SAVONIA	9216729	16850	21614.3	168	27.2	9.2	7/14/2000	MAN B&W	7S60MCC	171	16660	20
BAHAMIAN EXPRESS	9426324	20600	25899	179.7	27.6	10.7	Mar-10	MAN B&W	7S60MCC	171	16660	20.5
BALLENITA	9603609	26412	34123	208.93	29.79	11.6	Jun-13	MAN B&W	7L70MC	175	20930	22
BEETHOVEN	9506382	26374	34116	208.9	29.78	11.6	6/29/2012	MAN B&W	7L70MC	175	20930	22
BOMAR FULGENT	9330501	36483	42930	238	32	12	Aug-07	MAN B&W	7K90MCC	171	28773	23.5
BOMAR SPRING	9316359	32200	39063.6	210.8	32.3	12	8/11/2006	MAN B&W	7S70MC	175	22890	22.5
BOX EXPRESS	9733832	17907	21729.6	171.9	27.4	9.5	2/25/2016	Winterthur Gas & Diesel Ltd.	6RT-flex58T	171	13080	11.7
BOX VOYAGER	9418377	36087	42454	228.6	32.2	12	7/30/2010	Winterthur Gas & Diesel Ltd.	7RT-flex82C	171	31640	23.5
BUXHANSA	9150195	25713	33995	208	29.8	11.4	3/6/1998	Sulzer	6RTA72U	171	17940	21
CALIFORNIA TRADER	9771664	31370	37000	186	34.8	8.5	9/27/2017	MAN B&W	6G60ME-C	168.5	16080	16.3
CAPE MORETON	9308405	27786	37882.7	221.7	29.8	11.4	8/31/2005	MAN B&W	7L70MCC	175	21770	22

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
CHILOE ISLAND	9311749	28911	39316	222.1	30	12	10/31/2006	MAN B&W	7K80MC-C	171	25270	24
CHITTAGONG	9359715	27104	33662	199.9	32.2	11.3	4/27/2007	Sulzer	RTA84C 7 CY	171	21735	24.7
CIMBRIA	9241190	27779	39358	222.1 4	30	12	10/8/2002	MAN B&W	7K80MC-C	171	25270	24
COSCO ADEN	9484003	40447	49963	261.1	32.25	12.6	4/5/2012	MAN B&W	8K90MCC	171	36480	24.5
COSCO ASHDOD	9518335	40465	49955.9	261.1	32.25	11	8/12/2013	MAN B&W	8K90MCC	171	36480	24.5
COSCO COLOMBO	9484285	40447	49971	261.1	32.25	12.6	6/11/2012	MAN B&W	8K90MCC	171	36480	24.5
COSCO FOS	9484302	40447	49954	261	32.25	12.6	6/25/2012	MAN B&W	8K90MCC	171	36480	24.5
COSCO HAIFA	9484338	40465	49948.9	261.1	32.25	11	9/6/2012	MAN B&W	8K90MCC	171	36480	24.5
COSCO IZMIR	9484508	40465	49951.9	261.1	32.25	11	8/2/2013	MAN B&W	8K90MCC	171	36480	24.5
COSCO SANTOS	9484376	40465	49958.9	261.1	32.25	11	3/28/2013	MAN B&W	8K90MCC	171	36480	24.5
COSCO SAO PAULO	9484388	40465	49961.9	261.1	32.25	11	9/6/2012	MAN B&W	8K90MCC	171	36480	24.5
COSCO WELLINGTON	9484417	40465	49985.9	261.1	32.25	11	6/18/2013	MAN B&W	8K90MCC	171	36480	24.5
COUGAR	9014080	17156	22210	186.0 6	27.6	9.5	1/10/1992	MAN B&W	6S60MC	171	10590	21.6
CPO NORFOLK	9440813	41358	51727.3	262.1	32.2	12.5	5/29/2009	Winterthur Gas & Diesel Ltd.	8RTA82C	171	34000	24.2
CSCL KINGSTON	9400813	27104	33651	199.9	32.2	11.3	5/30/2008	MAN B&W	7S70MC	175	22890	22.5
CSCL MANZANILLO	9402639	26404	34194	208.9	29.8	11.6	Sep-09	MAN B&W	6K80MCC	171	21660	22
CSCL MONTEVIDEO	9385984	26404	34194	208.9	29.8	11.6	Sep-08	MAN B&W	6K80MCC	171	21660	22
CSCL SAN JOSE	9402615	26404	33726	208.9	29.8	11.6	Nov-08	MAN B&W	6K80MCC	171	21660	22
CSCL SANTIAGO	9386017	26404	33725	208.9	29.8	11.6	Nov-08	MAN B&W	6K80MCC	171	21660	22

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
CSCL SAO PAULO	9385996	26404	34194	208.9	29.8	11.6	Aug-08	MAN B&W	6K80MCC	171	21358	22
CUCKOO HUNTER	9238789	39941	24458	260.1	32.25	11	7/10/2003	MAN B&W	8K90MCC	171	36480	24.5
DAHLIA	9314959	28927	39159	222.16	30	12	6/20/2006	MAN B&W	7K80MC-C	171	25279	24
DEVA	9278105	40030	502829	260	32.25	11	3/15/2004	MAN B&W	8K90MCC	171	36480	24.5
E.R MARTINIQUE	9314985	28927	39200	222.17	30	12	1/25/2007	MAN B&W	7K80MC-C	171	25279	24
ELLA	9259379	27104	33216	199.9	32.2	11.3	3/26/2003	MAN B&W	7S70MC	175	22890	22.5
EM ANDROS	9259379	27104	33216	199.9	32.2	11.3	3/26/2003	MAN B&W	7S70MC	175	22890	22.5
EURO MAX	9232773	32284	39307	210.9	32.3	12	8/26/2002	MAN B&W	7S70MC	175	22890	22.5
EVER ABLE	9130509	14807	15606	165	27.1	8.52	7/29/1996	Wartsila	7RTA52U	171	10914	19.8
EVER ALLY	9130511	14807	15606	165	27.1	8.52	11/25/1996	Wartsila	7RTA52U	171	10914	19.8
EVER APEX	9130523	14807	15606	165	27.1	8.52	3/26/1997	Wartsila	7RTA52U	171	10914	19.8
EVER BLISS	9786932	32659	37546	211.9	32.8	-	2017	-	-	171	28880	22.2
FRISIA NUERNBERG	9470973	21842	28627	189.5	27.6	11.35	3/12/2010	MAN B&W	8S60ME-C7	171	18080	21
FRISIA ROTTERDAM	9299032	25406	33783.6	207.5	29.8	11.4	11/29/2004	MAN B&W	7L70MCC	175	22890	22
GH LESTE	9418377	36087	42454	228.6	32.2	12	7/30/2010	Winterthur Gas & Diesel Ltd.	7RT-flex82C	171	31640	23.5
GH ZONDA	9436472	36007	41973	231	32.2	12	9/8/2008	MAN B&W	7K90MCC	171	31920	23.4
GUAYAQUIL BRIDGE	9402641	26404	34194	208.97	29.8	11.6	Mar-10	MAN B&W	6K80MCC	171	21660	22
GUENTHER SCHULTE	9436434	35697	41500	231	32.2	12	May-08	MAN B&W	7K90MCC	171	31920	23.4
HAI LIAN	9232395	25630	33739	207.4	29.8	11.4	Jun-02	MAN B&W	6L70MC	175	17200	21

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
HAMMONIA BEROLINA	9336177	26435	34236.3	208.92	29.8	11.6	3/15/2007	MAN B&W	6K80MCC	171	21660	22
HANSA ROTENBURG	9401673	18326	23332	175.5	27.4	10.92	2/19/2009	MAN B&W	7S60MCC	171	16660	20.5
HAYLING ISLAND	9315886	28927	39200	222.2	30	12	11/1/2005	MAN B&W	7K80MC-C	171	25279	24
HS CHOPIN	9323027	38320	46344.6	246.9	32.2	12.3	10/2/2007	MAN B&W	9K80MC-C	171	32490	23.4
HS ONORE	9300972	32968	38608.6	212.8	32.2	12	5/4/2006	MAN B&W	8K80MC-C	171	28880	23
IBN AL ABBAR	9194490	16705	24376	183.2	27.6	10.1	3/12/1999	MAN B&W	6S60MC	171	10590	21.4
INTEGRA	9730854	17200	21512	172	27.6	9.5	12/29/2014	-	-	171	16660	-
IRENES RELIANCE	9315862	28592	39241	221.2	30	12	Sep-05	MAN B&W	7K80MC-C	171	25279	24
JPO VELA	9406180	41225	50420	265	32.25	12.6	8/26/2009	MAN B&W	8K90MCC	171	36480	24
KOTA JAYA	9205677	18502	24921	193	28	9.63	4/13/2000	Mitsubishi	8UEC60LS	170	13755	21.2
KOTA JUTA	9226839	18502	24935	193	28	9.63	4/10/2001	Mitsubishi	8UEC60LS	170	13755	21.2
KOTA NABIL	9356830	20902	25985	179.65	27.6	10.7	Mar-08	MAN B&W	7S60MCC	171	16660	20
KOTA NAGA	9362293	20902	25985	179.65	27.6	10.7	May-08	MAN B&W	7S60MCC	171	16660	20
KOTA NASTRAT	9494620	20902	25985	179.63	27.6	10.7	Dec-08	MAN B&W	7S60MCC	171	16660	20
KOTA NIPAH	9593696	20902	25944	179.75	27.6	10.7	Jul-11	MAN B&W	7S60MCC	171	16660	20
KOTA RANCAK	9296298	9678	13260	145.9	22.6	8.1	10/14/2005			171	6150	18.4
KOTA TENAGA	9251157	7683	10701	130.4	20	7.4	Nov-02	MAN B&W	8S35MC	178	6960	15.9
KOTA WARIS	9157404	16772	24636	184.5	27.6	10	11/21/1997	Mitsubishi	6UEC60LS	170	10592	19
KYAUK PHYU STAR	9009188	18487	24497	193	28	9.53	1/30/1992	Mitsubishi	8UEC60LS	170	13755	22.4
KYOTO TOWER	9384887	17229	21975	172	27.6	9.52	3/23/2007	MAN B&W	7S60MCC	171	16660	19.7

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
LAKONIA	9248679	28270	33297	213	32.2	11.5	12/21/2004	MAN B&W	7K80MC-C	171	25279	22.7
LEO PERDANA	9363390	27104	33423	199.9	32.2	11.28	11/14/2007	MAN B&W	7S70MC	175	22890	22.5
LOUDS ISLAND	9305013	27915	38103.5	215.13	29.8	11.55	9/9/2005	MAN B&W	7L70MC	175	22890	22.3
LYDIA	9377573	28048	37968	215.45	29.8	11.55	1/30/2009	MAN B&W	7L70MC	175	22890	22.3
MAERSK JALAN	9294161	27779	39241	221.2	30	12	Jul-05	MAN B&W	7K80MC-C	171	25279	24
MARIA SCHULTE	9309289	35975	42141.1	231	32.2	12	9/14/2006	MAN B&W	7K90MCC	171	31920	23.4
MARIA-KATHARINA S	9429326	26435	34264.2	208.8	29.8	11.6	1/7/2010	Winterthur Gas & Diesel Ltd.	7RT-flex82-B	171	31640	
MERATUS TOMINI	9374583	28050	38012.5	215.3	29.8	11.55	11/15/2007	MAN B&W	7L70MCC	175	22890	22.3
MERKUR TIDE	9162368	15929	22020	167.95	26.7	10.8	3/20/1998	Sulzer	7RTA62U	171	15995	21
MILLENIUM BRIGHT	9515606	17211	21933	172	27.6	9.517	6/26/2009	MAN B&W	7S60MC	171	15820	21.5
MIYUNHE	9228772	16738	24259	182.9	27.6	10	2000	MAN B&W	6S60MC	171	10590	20
MOROTAI	9132399	7260	9821	125.3	20	7.8	4/30/1996	MAN B&W	8S35MC	178	5669	15.9
MS EAGLE	9314997	28927	39200	222.2	30	12	4/10/2007	MAN B&W	7K80MC-C	171	25279	24
MS HAWK	9303819	28592	39418	222.2	30	12	6/29/1905	MAN B&W	7K80MC-C	171	25279	24
MSC CARLA 3	9124512	31730	34954	192.3	32.25	12.8	5/30/1997	Sulzer	6RTA84C	171	24300	22
MSC GIANNA	9152856	30280	35848	201.6	32.25	12.2	4/9/1998	MAN B&W	8K80MC-C	171	28880	22
MSC GIORGIA	8408818	22667	33823	187.6	28.4	11.1	1985	MAN B&W	6L70MC	175	25850	18
MSC IMMA	9124366	30280	35980	201.5	32.25	12.2	8/19/1996	MAN B&W	8K80MC-C	171	28880	22
MSC LUCIA	8413887	21887	31290	189.4	28.4	11.1	10/31/1985	MAN B&W	5L70MC	172	16350	17.2

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
MSC REUNION	9007831	23953	31826.3	181.5	31.4	10.3	6/14/1905	MAN B&W	7S60MC	171	16660	18
MV CIRCULAR QUAY	9436458	35991	42035	230.9	32.2	12	9/15/2009	MAN B&W	7K90MCC	171	28834	23.4
NAJADE	9326706	27915	38130.8	215.3	29.8	11.6	3/9/2007	MAN B&W	7L70MCC	175	22890	22.3
NAVIOS TEMPO	9404209	40541	50466	261	32.2	12.6	12/23/2009	MAN B&W	8K90MCC	171	36480	24.5
NAVIOS SPRING	9395953	40741	52360	258.9	32.2	12.6	2/25/2010	MAN B&W	8K90MCC	171	36480	24.5
NORDCLAIRE	9744673	18826	23512.3	170	28.1	9.5	3/21/2016	MAN B&W	6S60MC	171	14280	18.8
NORDWOGE	9294549	26611	34704	210	30.1	11.5	2/7/2006	MAN B&W	8S70MCC	175	26160	22.1
NORTHERN DEFENDER	9329643	35975	42121.1	231	32.2	12	12/17/2007	MAN B&W	7K90MCC	171	31920	23.4
NORTHERN DEMOCRAT	9391787	36007	41986.7	230.9	32.2	12	9/29/2009	MAN B&W	7K90MCC	171	31920	23.4
NORTHERN DIAMOND	9405033	36007	42000	230.9	32.2	12	12/18/2008	MAN B&W	7K90MCC	171	31920	23.4
NORTHERN VIVACITY	9304966	27437	37856	221.7	29.8	11.4	9/29/2005	MAN B&W	7L70MC	175	22890	22
OLIVIA	9374571	28050	38096.3	215.3	29.8	11.5	6/29/2007	MAN B&W	7L70MC	175	22890	22
OLYMPIA	9765574	17907	22000	171.9	27.4	9.5	11/21/2017	Winterthur Gas & Diesel Ltd.	6RT-flex58T	171	13080	14.6
OTTO	9203461	20624	25850	179.7	27.6	10.7	1999	MAN B&W	6L70MC	175	25850	15
PHILIPPA SCHULTE	9329629	35975	42164.7	230.9	32.2	12	1/16/2007	MAN B&W	7K90MCC	171	31920	23.4
PONA	9349875	27968	37905.1	221.75	29.8	11.4	2/16/2007	Mitsubishi	7UEC68LSE	169	21770	22
PORT ADELAIDE	9363429	27104	33704	199.9	32.2	11.3	11/6/2007	MAN B&W	7S70MC	175	21735	22.5
POSEN	9349887	27968	37951	221.75	29.8	11.4	8/24/2007	Mitsubishi	7UEL68LSE	169	21770	22
PRINCESS OF LUCK	9159842	16705	24346	183.2	27.6	10.1	7/14/1997	MAN B&W	6S60MC	171	12240	19

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
PROTOSTAR N	9360257	28007	37904.9	221.75	29.8	11.4	4/19/2007	Mitsubishi	7UEL68LSE	169	21770	22
QINGDAO	9359727	27104	33648	199.9	32.2	11.3	Jul-07	Sulzer	-	175	18000	22.5
QUEEN OF LUCK	9088512	16316	23292	164	27.5	10.8	3/1/1995	MAN B&W	7L60MC	171	13125	21
RUBINA SCHULTE	9315836	28927	38200	222.2	30	12	1/28/2005	MAN B&W	7K80MC-C	171	25270	24
SARAH SCHULTE	9294159	28592	39383	222.14	30	12	12/4/2005	MAN B&W	7K80MC-C	171	25270	24
SEASPAN FRASER	9351608	41225	50382	265	32.3	12.6	6/1/2010	MAN B&W	8K90MCC	171	36480	24.5
SEASPAN SANTOS	9301835	39941	50869	260.1	32.3	12.7	Nov-06	MAN B&W	8K90MCC	171	36480	24.5
SEASPAN VANCOUVER	9290098	39941	50600	260.1	32.25	12.6	2/16/2005	MAN B&W	8K90MCC	171	36480	24.5
SELATAN DAMAI	9353931	6245	8150	115.4	20.82	7	Jul-07	YAN	-		3310	14
SFL AVON	9455909	18321	28543	175.4	27.4	10.9	10/12/2010	MAN B&W	7S60MCC	171	16660	20.5
SINAR BITUNG	9412799	13596	17815	161.85	25.6	9.1	7/6/2007	MAN B&W	7S50MCC	171	12640	18.3
SINAR SABANG	9435234	18321	23350	175	27.4	10.92	21/10/2008	MAN B&W	7S60MC	171	16660	20.5
SINAR SUMBA	9435222	18321	23350	175	27.4	10.92	6/23/2008	MAN B&W	7S60MC	171	16660	20.5
SITC SURABAYA	9320025	27971	37785.6	221.6	29.8	16.4	6/29/2006	MAN B&W	7L70MCC	175	22890	-
SONGA HAYDN	9392561	35981	41989.2	231	32.2	12	3/25/2010	MAN B&W	7K90MCC	171	28834	23.4
SOUL OF LUCK	9148647	16915	21519	168.1	27.2	9.2	10/13/1997	MAN B&W	6S60MC	171	12240	19.5
SPECTRUM N	9429314	26435	34333.9	208.9	29.8	11.6	6/22/2009	Winterthur Gas & Diesel Ltd.	7RT-flex68-B	171	21490	22
ST ISLAND	9532276	27094	33280	199.9	32.2	11.3	Oct-10	MAN B&W	7S70MC	175	21771	22.5
ST. MARY	9219252	16900	19700	168	27.2	9.2	Jan-01	MAN B&W	7S60MC	171	15798	20

SHIP'S NAME	IMO NUMBER	GROSS TONNAGE (GT)	SUMMER DEADWEIGHT (DWT)	LOA (m)	Breadth (m)	Draught (m)	Year Built	Engine Brand	Engine Model	SFOC (g/kWh)	Engine Power (kW)	Max Speed (knot)
STAR OF LUCK	9148659	16915	19260	168	27	9.22	12/29/1997	MAN B&W	6S60MC	171	12438	19.5
TR ARAMIS	9784661	31370	36923	186	34802	8.5	7/6/2017	MAN B&W	6G60ME-C	168.5	16080	-
TR ATHOS	9784647	31370	37000	186	34.8	8.5	5/19/2017	-	-	168.5	16080	-
TS TAICHUNG	9359727	27104	33648	199.9	32.2	11.3	30-07-2007	Sulzer	-	175	18000	22.5
UNI AMPLE	9143336	14796	15477	165	27.1	8.5	8/11/1997	Sulzer	7RTA52U	171	10914	18.7
UNI FORTUNA	9330496	36483	42882	238.9	32.3	12	Jun-07	MAN B&W	7K90MCC	171	31920	23.5
URU BHUM	9293234	24955	31805	194.93	32.26	11.4	2/25/2005	Mitsubishi	7UEC68LSE	169	20580	21.5
VALERIE SCHULTE	9315874	28927	39200	221	30	12	6/20/2005	MAN B&W	7K80MC-C	171	25270	24
VENETIA	9400203	42609	52788	268.8	32.2	12.5	Oct-10	Sulzer	7RT-flex96C	171	40044	24.5
VICTORIA SCHULTE	9312418	25406	33900	207.4	29.8	11.4	7/6/2005	MAN B&W	7L70MCC	175	22890	22
WAN HAI 212	9048586	17138	23877	174.6	27	9.1	3/1/1993	MAN B&W	7S50MCC	171	11060	17.5
WAN HAI 216	9059145	17138	23837	174.6	27	9.85	2/25/1994	MAN B&W	7S50MCC	171	11060	17.5
WAN HAI 231	9208150	17751	21052	191.5	28	9.5	2/10/2000	MAN B&W	7S60MCC	171	16660	21
WAN HAI 271	9493250	16776	17850	172.1	27.3	8.5	10/14/2011	MAN B&W	7S60MC	171	16660	19.8
WAN HAI 273	9493274	16776	21762	172.1	27.3	8.5	2/15/2012	MAN B&W	7S60MC	171	15820	19.8
WAN HAI 281	9182019	17609	23752	182.8	28	9.53	3/31/1998	MAN B&W	6S60MC	171	10590	20.7
WARNOW CHIEF	9449857	17068	21191	180.4	25	9.5	24/10/2009	MAN B&W	8L58/64	171	11120	19.6
WELLINGTON STRAIT	9516777	18358	23367.8	175.5	27.4	10.9	4/20/2012	MAN B&W	7S60MC	171	16660	20.5

Attachment Table A.2. Ship’s Discharge Water per Arrival (m^3)

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
AEGEAN EXPRESS	7	15095	39.976	2.153189	3.380488	1.229268293
ALIDRA	10	17167	66.64	3.021443	3.380488	1.229268293
AMALTHEA	1	42609	120.088	18.83823	3.380488	1.229268293
ANNA-S	4	26435	82.98	5.619662	3.380488	1.229268293
ARICA BRIDGE	4	27094	83.47	8.880365	3.380488	1.229268293
AS CONSTANTINA	3	27786	81.86	12.04201	3.380488	1.229268293
AS SAVONIA	10	16850	66.64	3.91169	3.380488	1.229268293
BAHAMIAN EXPRESS	7	20600	66.64	4.611676	3.380488	1.229268293
BALLENITA	10	26412	81.86	4.618052	3.380488	1.229268293
BEETHOVEN	9	26374	81.86	6.201384	3.380488	1.229268293
BOMAR FULGENT	3	36483	97.546	6.282921	3.380488	1.229268293
BOMAR SPRING	5	32200	85.78	3.682957	3.380488	1.229268293
BOX EXPRESS	3	17907	52.32	5.515145	3.380488	1.229268293
BOX VOYAGER	3	36087	103.28	11.79373	3.380488	1.229268293
BUXHANSA	1	25713	71.76	6.74412	3.380488	1.229268293
CALIFORNIA TRADER	3	31370	64.32	6.530039	3.380488	1.229268293
CAPE MORETON	8	27786	83.54	9.790908	3.380488	1.229268293
CHILOE ISLAND	10	28911	90.54	6.098842	3.380488	1.229268293
CHITTAGONG	13	27104	83.47	10.43343	3.380488	1.229268293

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
CIMBRIA	6	27779	90.54	10.11893	3.380488	1.229268293
COSCO ADEN	2	40447	112.96	13.95332	3.380488	1.229268293
COSCO ASHDOD	1	40465	112.96	15.60029	3.380488	1.229268293
COSCO COLOMBO	2	40447	112.96	12.86059	3.380488	1.229268293
COSCO FOS	1	40447	112.96	14.82541	3.380488	1.229268293
COSCO HAIFA	1	40465	112.96	19.78851	3.380488	1.229268293
COSCO IZMIR	1	40465	112.96	16.726	3.380488	1.229268293
COSCO SANTOS	2	40465	112.96	18.24655	3.380488	1.229268293
COSCO SAO PAULO	1	40465	112.96	23.61318	3.380488	1.229268293
COSCO WELLINGTON	1	40465	112.96	20.0712	3.380488	1.229268293
COUGAR	28	17156	42.36	2.892738	3.380488	1.229268293
CPO NORFOLK	10	41358	108	16.04617	3.380488	1.229268293
CSCL KINGSTON	20	27104	85.78	5.091078	3.380488	1.229268293
CSCL MANZANILLO	9	26404	83.32	6.959798	3.380488	1.229268293
CSCL MONTEVIDEO	4	26404	83.32	8.569548	3.380488	1.229268293
CSCL SAN JOSE	8	26404	83.32	10.83395	3.380488	1.229268293
CSCL SANTIAGO	11	26404	83.32	7.23979	3.380488	1.229268293
CSCL SAO PAULO	7	26404	82.716	9.858409	3.380488	1.229268293
CUCKOO HUNTER	5	39941	112.96	16.54929	3.380488	1.229268293
DAHLIA	8	28927	90.558	6.439959	3.380488	1.229268293
DEVA	7	40030	112.96	16.29663	3.380488	1.229268293
E.R MARTINIQUE	1	28927	90.558	13.71744	3.380488	1.229268293

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
ELLA	2	27104	85.78	10.31089	3.380488	1.229268293
EM ANDROS	10	27104	85.78	8.353349	3.380488	1.229268293
EURO MAX	1	32284	85.78	12.34293	3.380488	1.229268293
EVER ABLE	17	14807	43.656	1.94989	3.380488	1.229268293
EVER ALLY	16	14807	43.656	2.30987	3.380488	1.229268293
EVER APEX	11	14807	43.656	1.5888	3.380488	1.229268293
EVER BLISS	1	32659	97.76	14.65221	3.380488	1.229268293
FRISIA NUERNBERG	6	21842	72.32	9.502262	3.380488	1.229268293
FRISIA ROTTERDAM	2	25406	85.78	7.657227	3.380488	1.229268293
GH LESTE	2	36087	103.28	5.544773	3.380488	1.229268293
GH ZONDA	5	36007	103.84	10.88843	3.380488	1.229268293
GUAYAQUIL BRIDGE	4	26404	83.32	7.377632	3.380488	1.229268293
GUENTHER SCHULTE	3	35697	103.84	5.488958	3.380488	1.229268293
HAI LIAN	2	25630	68.8	12.21502	3.380488	1.229268293
HAMMONIA BEROLINA	6	26435	83.32	5.104292	3.380488	1.229268293
HANSA ROTENBURG	1	18326	66.64	5.821334	3.380488	1.229268293
HAYLING ISLAND	10	28927	90.558	4.458433	3.380488	1.229268293
HS CHOPIN	7	38320	104.98	6.385114	3.380488	1.229268293
HS ONORE	2	32968	97.76	5.675657	3.380488	1.229268293
IBN AL ABBAR	2	16705	42.36	4.686923	3.380488	1.229268293
INTEGRA	4	17200	66.64	10.96398	3.380488	1.229268293
IRENES RELIANCE	4	28592	90.558	4.293306	3.380488	1.229268293

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
JPO VELA	1	41225	112.96	16.74178	3.380488	1.229268293
KOTA JAYA	28	18502	55.02	2.876808	3.380488	1.229268293
KOTA JUTA	18	18502	55.02	3.210723	3.380488	1.229268293
KOTA NABIL	2	20902	66.64	6.914649	3.380488	1.229268293
KOTA NAGA	3	20902	66.64	6.770594	3.380488	1.229268293
KOTA NASTRAT	3	20902	66.64	6.543393	3.380488	1.229268293
KOTA NIPAH	1	20902	66.64	5.477335	3.380488	1.229268293
KOTA RANCAK	4	9678	24.6	1.004516	3.219512	1.170731707
KOTA TENAGA	1	7683	27.84	1.229161	3.219512	1.170731707
KOTA WARIS	1	16772	42.368	2.082028	3.380488	1.229268293
KYAUK PHYU STAR	12	18487	55.02	3.239648	3.380488	1.229268293
KYOTO TOWER	1	17229	66.64	5.94084	3.380488	1.229268293
LAKONIA	2	28270	90.558	11.73717	3.380488	1.229268293
LEO PERDANA	14	27104	85.78	9.492442	3.380488	1.229268293
LOUDS ISLAND	16	27915	85.78	14.61836	3.380488	1.229268293
LYDIA	14	28048	85.78	17.14761	3.380488	1.229268293
MAERSK JALAN	1	27779	90.558	11.83962	3.380488	1.229268293
MARIA SCHULTE	4	35975	103.84	12.12988	3.380488	1.229268293
MARIA-KATHARINA S	1	26435	103.28	11.2496	3.380488	1.229268293
MERATUS TOMINI	1	28050	85.78	13.03587	3.380488	1.229268293
MERKUR TIDE	2	15929	63.98	2.880971	3.380488	1.229268293
MILLENIUM BRIGHT	11	17211	63.28	3.067289	3.380488	1.229268293

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
MIYUNHE	17	16738	42.36	1.894463	3.380488	1.229268293
MOROTAI	1	7260	22.676	1.184586	3.219512	1.170731707
MS EAGLE	1	28927	90.558	5.476501	3.380488	1.229268293
MS HAWK	6	28592	90.558	6.047962	3.380488	1.229268293
MSC CARLA 3	10	31730	88.6	3.569938	3.380488	1.229268293
MSC GIANNA	16	30280	97.76	4.688022	3.380488	1.229268293
MSC GIORGIA	1	22667	91.7	6.324369	3.380488	1.229268293
MSC IMMA	16	30280	97.76	5.710222	3.380488	1.229268293
MSC LUCIA	26	21887	65.4	3.133852	3.380488	1.229268293
MSC REUNION	12	23953	66.64	3.174705	3.380488	1.229268293
MV CIRCULAR QUAY	4	35991	97.668	9.533358	3.380488	1.229268293
NAJADE	13	27915	85.78	7.817305	3.380488	1.229268293
NAVIOS TEMPO	1	40541	112.96	14.63204	3.380488	1.229268293
NAVIOUS BRIDGE	1	40741	112.96	6.273094	3.380488	1.229268293
NORDCLAIRE	1	18826	57.12	5.862671	3.380488	1.229268293
NORDWOGE	6	26611	92.32	14.40233	3.380488	1.229268293
NORTHERN DEFENDER	8	35975	103.84	7.636811	3.380488	1.229268293
NORTHERN DEMOCRAT	8	36007	103.84	6.653282	3.380488	1.229268293
NORTHERN DIAMOND	9	36007	103.84	7.7038	3.380488	1.229268293
NORTHERN VIVACITY	6	27437	85.78	7.734669	3.380488	1.229268293
OLIVIA	4	28050	85.78	8.701405	3.380488	1.229268293
OLYMPIA	1	17907	52.32	6.376887	3.380488	1.229268293

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
OTTO	1	20624	91.7	4.348004	3.380488	1.229268293
PHILIPPA SCHULTE	2	35975	103.84	16.38598	3.380488	1.229268293
PONA	3	27968	83.54	10.43796	3.380488	1.229268293
PORT ADELAIDE	2	27104	83.47	14.16877	3.380488	1.229268293
POSEN	3	27968	83.54	3.972919	3.380488	1.229268293
PRINCESS OF LUCK	2	16705	48.96	7.205871	3.380488	1.229268293
PROTOSTAR N	10	28007	83.54	8.339386	3.380488	1.229268293
QINGDAO	0	27104	72	8.398417	3.380488	1.229268293
QUEEN OF LUCK	5	16316	52.5	3.157038	3.380488	1.229268293
RUBINA SCHULTE	9	28927	90.54	4.265448	3.380488	1.229268293
SARAH SCHULTE	2	28592	90.54	3.97296	3.380488	1.229268293
SEASPAN FRASER	8	41225	112.96	13.95332	3.380488	1.229268293
SEASPAN SANTOS	6	39941	112.96	15.46999	3.380488	1.229268293
SEASPAN VANCOUVER	1	39941	112.96	15.50195	3.380488	1.229268293
SELATAN DAMAI	11	6245	13.24	1	3.219512	1.170731707
SFL AVON	1	18321	66.64	5.923462	3.380488	1.229268293
SINAR BITUNG	2	13596	50.56	2.35099	3.380488	1.229268293
SINAR SABANG	38	18321	66.64	3.151865	3.380488	1.229268293
SINAR SUMBA	21	18321	66.64	2.880948	3.380488	1.229268293
SITC SURABAYA	2	27971	85.78	11.9789	3.380488	1.229268293
SONGA HAYDN	1	35981	97.668	5.253817	3.380488	1.229268293
SOUL OF LUCK	3	16915	48.96	3.373569	3.380488	1.229268293

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m^3)	Sludge (m^3)	Greywater (m^3)	Blackwater (m^3)
SPECTRUM N	10	26435	82.98	7.708386	3.380488	1.229268293
ST ISLAND	15	27094	83.542	8.426501	3.380488	1.229268293
ST. MARY	5	16900	63.192	2.751266	3.380488	1.229268293
STAR OF LUCK	12	16915	49.752	2.76325	3.380488	1.229268293
TR ARAMIS	2	31370	64.32	8.444862	3.380488	1.229268293
TR ATHOS	5	31370	64.32	12.25579	3.380488	1.229268293
TS TAICHUNG	5	27104	72	5.358224	3.380488	1.229268293
UNI AMPLE	6	14796	43.656	1.98863	3.380488	1.229268293
UNI FORTUNA	7	36483	103.84	6.553979	3.380488	1.229268293
URU BHUM	14	24955	81.16	7.646079	3.380488	1.229268293
VALERIE SCHULTE	9	28927	90.54	4.514727	3.380488	1.229268293
VENETIA	2	42609	120.088	14.83183	3.380488	1.229268293
VICTORIA SCHULTE	1	25406	85.78	3.620885	3.380488	1.229268293
WAN HAI 212	15	17138	44.24	6.162374	3.380488	1.229268293
WAN HAI 216	15	17138	44.24	4.368265	3.380488	1.229268293
WAN HAI 231	5	17751	66.64	6.839783	3.380488	1.229268293
WAN HAI 271	3	16776	66.64	5.650256	3.380488	1.229268293
WAN HAI 273	3	16776	63.28	5.673723	3.380488	1.229268293
WAN HAI 281	6	17609	42.36	4.37653	3.380488	1.229268293
WARNOW CHIEF	47	17068	44.48	2.266849	3.380488	1.229268293
WELLINGTON STRAIT	6	18358	66.64	6.92779	3.380488	1.229268293

Attachment Table A.3. Fees of waste handling management

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m3)	Sludge (m3)	Greywater (m3)	Blackwater (m3)	Price according to GRT (Euro)	Rupiah	per year
AEGEAN EXPRESS	7	15095	39.976	2.153189	3.380488	1.229268293	1000	16,108,390	112,758,730
ALIDRA	10	17167	66.64	3.021443	3.380488	1.229268293	1000	16,108,390	161,083,900
AMALTHEA	1	42609	120.088	18.83823	3.380488	1.229268293	1600	25,773,424	25,773,424
ANNA-S	4	26435	82.98	5.619662	3.380488	1.229268293	1600	25,773,424	103,093,696
ARICA BRIDGE	4	27094	83.47	8.880365	3.380488	1.229268293	1600	25,773,424	103,093,696
AS CONSTANTINA	3	27786	81.86	12.04201	3.380488	1.229268293	1600	25,773,424	77,320,272
AS SAVONIA	10	16850	66.64	3.91169	3.380488	1.229268293	1000	16,108,390	161,083,900
BAHAMIAN EXPRESS	7	20600	66.64	4.611676	3.380488	1.229268293	1000	16,108,390	112,758,730
BALLENITA	10	26412	81.86	4.618052	3.380488	1.229268293	1600	25,773,424	257,734,240
BEETHOVEN	9	26374	81.86	6.201384	3.380488	1.229268293	1600	25,773,424	231,960,816
BOMAR FULGENT	3	36483	97.546	6.282921	3.380488	1.229268293	1600	25,773,424	77,320,272
BOMAR SPRING	5	32200	85.78	3.682957	3.380488	1.229268293	1600	25,773,424	128,867,120
BOX EXPRESS	3	17907	52.32	5.515145	3.380488	1.229268293	1000	16,108,390	48,325,170
BOX VOYAGER	3	36087	103.28	11.79373	3.380488	1.229268293	1600	25,773,424	77,320,272
BUXHANSA	1	25713	71.76	6.74412	3.380488	1.229268293	1600	25,773,424	25,773,424
CALIFORNIA TRADER	3	31370	64.32	6.530039	3.380488	1.229268293	1600	25,773,424	77,320,272
CAPE MORETON	8	27786	83.54	9.790908	3.380488	1.229268293	1600	25,773,424	206,187,392
CHILOE ISLAND	10	28911	90.54	6.098842	3.380488	1.229268293	1600	25,773,424	257,734,240
CHITTAGONG	13	27104	83.47	10.43343	3.380488	1.229268293	1600	25,773,424	335,054,512
CIMBRIA	6	27779	90.54	10.11893	3.380488	1.229268293	1600	25,773,424	154,640,544

SHIP'S NAME	**Times of Arrival per Year**	**Gross Tonnage**	**Oily Bilge (m3)**	**Sludge (m3)**	**Greywater (m3)**	**Blackwater (m3)**	Price according to GRT (Euro)	Rupiah	per year
COSCO ADEN	2	40447	112.96	13.95332	3.380488	1.229268293	1600	25,773,424	51,546,848
COSCO ASHDOD	1	40465	112.96	15.60029	3.380488	1.229268293	1600	25,773,424	25,773,424
COSCO COLOMBO	2	40447	112.96	12.86059	3.380488	1.229268293	1600	25,773,424	51,546,848
COSCO FOS	1	40447	112.96	14.82541	3.380488	1.229268293	1600	25,773,424	25,773,424
COSCO HAIFA	1	40465	112.96	19.78851	3.380488	1.229268293	1600	25,773,424	25,773,424
COSCO IZMIR	1	40465	112.96	16.726	3.380488	1.229268293	1600	25,773,424	25,773,424
COSCO SANTOS	2	40465	112.96	18.24655	3.380488	1.229268293	1600	25,773,424	51,546,848
COSCO SAO PAULO	1	40465	112.96	23.61318	3.380488	1.229268293	1600	25,773,424	25,773,424
COSCO WELLINGTON	1	40465	112.96	20.0712	3.380488	1.229268293	1600	25,773,424	25,773,424
COUGAR	28	17156	42.36	2.892738	3.380488	1.229268293	1000	16,108,390	451,034,920
CPO NORFOLK	10	41358	108	16.04617	3.380488	1.229268293	1600	25,773,424	257,734,240
CSCL KINGSTON	20	27104	85.78	5.091078	3.380488	1.229268293	1600	25,773,424	515,468,480
CSCL MANZANILLO	9	26404	83.32	6.959798	3.380488	1.229268293	1600	25,773,424	231,960,816
CSCL MONTEVIDEO	4	26404	83.32	8.569548	3.380488	1.229268293	1600	25,773,424	103,093,696
CSCL SAN JOSE	8	26404	83.32	10.83395	3.380488	1.229268293	1600	25,773,424	206,187,392
CSCL SANTIAGO	11	26404	83.32	7.23979	3.380488	1.229268293	1600	25,773,424	283,507,664
CSCL SAO PAULO	7	26404	82.716	9.858409	3.380488	1.229268293	1600	25,773,424	180,413,968
CUCKOO HUNTER	5	39941	112.96	16.54929	3.380488	1.229268293	1600	25,773,424	128,867,120
DAHLIA	8	28927	90.558	6.439959	3.380488	1.229268293	1600	25,773,424	206,187,392
DEVA	7	40030	112.96	16.29663	3.380488	1.229268293	1600	25,773,424	180,413,968
E.R MARTINIQUE	1	28927	90.558	13.71744	3.380488	1.229268293	1600	25,773,424	25,773,424

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m3)	Sludge (m3)	Greywater (m3)	Blackwater (m3)	Price according to GRT (Euro)	Rupiah	per year
ELLA	2	27104	85.78	10.31089	3.380488	1.229268293	1600	25,773,424	51,546,848
EM ANDROS	10	27104	85.78	8.353349	3.380488	1.229268293	1600	25,773,424	257,734,240
EURO MAX	1	32284	85.78	12.34293	3.380488	1.229268293	1600	25,773,424	25,773,424
EVER ABLE	17	14807	43.656	1.94989	3.380488	1.229268293	1000	16,108,390	273,842,630
EVER ALLY	16	14807	43.656	2.30987	3.380488	1.229268293	1000	16,108,390	257,734,240
EVER APEX	11	14807	43.656	1.5888	3.380488	1.229268293	1000	16,108,390	177,192,290
EVER BLISS	1	32659	97.76	14.65221	3.380488	1.229268293	1600	25,773,424	25,773,424
FRISIA NUERNBERG	6	21842	72.32	9.502262	3.380488	1.229268293	1000	16,108,390	96,650,340
FRISIA ROTTERDAM	2	25406	85.78	7.657227	3.380488	1.229268293	1600	25,773,424	51,546,848
GH LESTE	2	36087	103.28	5.544773	3.380488	1.229268293	1600	25,773,424	51,546,848
GH ZONDA	5	36007	103.84	10.88843	3.380488	1.229268293	1600	25,773,424	128,867,120
GUAYAQUIL BRIDGE	4	26404	83.32	7.377632	3.380488	1.229268293	1600	25,773,424	103,093,696
GUENTHER SCHULTE	3	35697	103.84	5.488958	3.380488	1.229268293	1600	25,773,424	77,320,272
HAI LIAN	2	25630	68.8	12.21502	3.380488	1.229268293	1600	25,773,424	51,546,848
HAMMONIA BEROLINA	6	26435	83.32	5.104292	3.380488	1.229268293	1600	25,773,424	154,640,544
HANSA ROTENBURG	1	18326	66.64	5.821334	3.380488	1.229268293	1000	16,108,390	16,108,390
HAYLING ISLAND	10	28927	90.558	4.458433	3.380488	1.229268293	1600	25,773,424	257,734,240
HS CHOPIN	7	38320	104.98	6.385114	3.380488	1.229268293	1600	25,773,424	180,413,968
HS ONORE	2	32968	97.76	5.675657	3.380488	1.229268293	1600	25,773,424	51,546,848
IBN AL ABBAR	2	16705	42.36	4.686923	3.380488	1.229268293	1000	16,108,390	32,216,780

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m3)	Sludge (m3)	Greywater (m3)	Blackwater (m3)	Price according to GRT (Euro)	Rupiah	per year
INTEGRA	4	17200	66.64	10.96398	3.380488	1.229268293	1000	16,108,390	64,433,560
IRENES RELIANCE	4	28592	90.558	4.293306	3.380488	1.229268293	1600	25,773,424	103,093,696
JPO VELA	1	41225	112.96	16.74178	3.380488	1.229268293	1600	25,773,424	25,773,424
KOTA JAYA	28	18502	55.02	2.876808	3.380488	1.229268293	1000	16,108,390	451,034,920
KOTA JUTA	18	18502	55.02	3.210723	3.380488	1.229268293	1000	16,108,390	289,951,020
KOTA NABIL	2	20902	66.64	6.914649	3.380488	1.229268293	1000	16,108,390	32,216,780
KOTA NAGA	3	20902	66.64	6.770594	3.380488	1.229268293	1000	16,108,390	48,325,170
KOTA NASTRAT	3	20902	66.64	6.543393	3.380488	1.229268293	1000	16,108,390	48,325,170
KOTA NIPAH	1	20902	66.64	5.477335	3.380488	1.229268293	1000	16,108,390	16,108,390
KOTA RANCAK	4	9678	24.6	1.004516	3.219512	1.170731707	600	9,665,034	38,660,136
KOTA TENAGA	1	7683	27.84	1.229161	3.219512	1.170731707	600	9,665,034	9,665,034
KOTA WARIS	1	16772	42.368	2.082028	3.380488	1.229268293	1000	16,108,390	16,108,390
KYAUK PHYU STAR	12	18487	55.02	3.239648	3.380488	1.229268293	1000	16,108,390	193,300,680
KYOTO TOWER	1	17229	66.64	5.94084	3.380488	1.229268293	1000	16,108,390	16,108,390
LAKONIA	2	28270	90.558	11.73717	3.380488	1.229268293	1600	25,773,424	51,546,848
LEO PERDANA	14	27104	85.78	9.492442	3.380488	1.229268293	1600	25,773,424	360,827,936
LOUDS ISLAND	16	27915	85.78	14.61836	3.380488	1.229268293	1600	25,773,424	412,374,784
LYDIA	14	28048	85.78	17.14761	3.380488	1.229268293	1600	25,773,424	360,827,936
MAERSK JALAN	1	27779	90.558	11.83962	3.380488	1.229268293	1600	25,773,424	25,773,424
MARIA SCHULTE	4	35975	103.84	12.12988	3.380488	1.229268293	1600	25,773,424	103,093,696
MARIA-KATHARINA S	1	26435	103.28	11.2496	3.380488	1.229268293	1600	25,773,424	25,773,424

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m3)	Sludge (m3)	Greywater (m3)	Blackwater (m3)	Price according to GRT (Euro)	Rupiah	per year
MERATUS TOMINI	1	28050	85.78	13.03587	3.380488	1.229268293	1600	25,773,424	25,773,424
MERKUR TIDE	2	15929	63.98	2.880971	3.380488	1.229268293	1000	16,108,390	32,216,780
MILLENIUM BRIGHT	11	17211	63.28	3.067289	3.380488	1.229268293	1000	16,108,390	177,192,290
MIYUNHE	17	16738	42.36	1.894463	3.380488	1.229268293	1000	16,108,390	273,842,630
MOROTAI	1	7260	22.676	1.184586	3.219512	1.170731707	600	9,665,034	9,665,034
MS EAGLE	1	28927	90.558	5.476501	3.380488	1.229268293	1600	25,773,424	25,773,424
MS HAWK	6	28592	90.558	6.047962	3.380488	1.229268293	1600	25,773,424	154,640,544
MSC CARLA 3	10	31730	88.6	3.569938	3.380488	1.229268293	1600	25,773,424	257,734,240
MSC GIANNA	16	30280	97.76	4.688022	3.380488	1.229268293	1600	25,773,424	412,374,784
MSC GIORGIA	1	22667	91.7	6.324369	3.380488	1.229268293	1000	16,108,390	16,108,390
MSC IMMA	16	30280	97.76	5.710222	3.380488	1.229268293	1600	25,773,424	412,374,784
MSC LUCIA	26	21887	65.4	3.133852	3.380488	1.229268293	1000	16,108,390	418,818,140
MSC REUNION	12	23953	66.64	3.174705	3.380488	1.229268293	1000	16,108,390	193,300,680
MV CIRCULAR QUAY	4	35991	97.668	9.533358	3.380488	1.229268293	1600	25,773,424	103,093,696
NAJADE	13	27915	85.78	7.817305	3.380488	1.229268293	1600	25,773,424	335,054,512
NAVIOS TEMPO	1	40541	112.96	14.63204	3.380488	1.229268293	1600	25,773,424	25,773,424
NAVIOUS BRIDGE	1	40741	112.96	6.273094	3.380488	1.229268293	1600	25,773,424	25,773,424
NORDCLAIRE	1	18826	57.12	5.862671	3.380488	1.229268293	1000	16,108,390	16,108,390
NORDWOGE	6	26611	92.32	14.40233	3.380488	1.229268293	1600	25,773,424	154,640,544
NORTHERN DEFENDER	8	35975	103.84	7.636811	3.380488	1.229268293	1600	25,773,424	206,187,392
NORTHERN DEMOCRAT	8	36007	103.84	6.653282	3.380488	1.229268293	1600	25,773,424	206,187,392

SHIP'S NAME	Times of Arrival per Year	Gross Tonnage	Oily Bilge (m3)	Sludge (m3)	Greywater (m3)	Blackwater (m3)	Price according to GRT (Euro)	Rupiah	per year
NORTHERN DIAMOND	9	36007	103.84	7.7038	3.380488	1.229268293	1600	25,773,424	231,960,816
NORTHERN VIVACITY	6	27437	85.78	7.734669	3.380488	1.229268293	1600	25,773,424	154,640,544
OLIVIA	4	28050	85.78	8.701405	3.380488	1.229268293	1600	25,773,424	103,093,696
OLYMPIA	1	17907	52.32	6.376887	3.380488	1.229268293	1000	16,108,390	16,108,390
OTTO	1	20624	91.7	4.348004	3.380488	1.229268293	1000	16,108,390	16,108,390
PHILIPPA SCHULTE	2	35975	103.84	16.38598	3.380488	1.229268293	1600	25,773,424	51,546,848
PONA	3	27968	83.54	10.43796	3.380488	1.229268293	1600	25,773,424	77,320,272
PORT ADELAIDE	2	27104	83.47	14.16877	3.380488	1.229268293	1600	25,773,424	51,546,848
POSEN	3	27968	83.54	3.972919	3.380488	1.229268293	1600	25,773,424	77,320,272
PRINCESS OF LUCK	2	16705	48.96	7.205871	3.380488	1.229268293	1000	16,108,390	32,216,780
PROTOSTAR N	10	28007	83.54	8.339386	3.380488	1.229268293	1600	25,773,424	257,734,240
QINGDAO	0	27104	72	8.398417	3.380488	1.229268293	1600	25,773,424	0
QUEEN OF LUCK	5	16316	52.5	3.157038	3.380488	1.229268293	1000	16,108,390	80,541,950
RUBINA SCHULTE	9	28927	90.54	4.265448	3.380488	1.229268293	1600	25,773,424	231,960,816
SARAH SCHULTE	2	28592	90.54	3.97296	3.380488	1.229268293	1600	25,773,424	51,546,848
SEASPAN FRASER	8	41225	112.96	13.95332	3.380488	1.229268293	1600	25,773,424	206,187,392
SEASPAN SANTOS	6	39941	112.96	15.46999	3.380488	1.229268293	1600	25,773,424	154,640,544
SEASPAN VANCOUVER	1	39941	112.96	15.50195	3.380488	1.229268293	1600	25,773,424	25,773,424
SELATAN DAMAI	11	6245	13.24	1	3.219512	1.170731707	600	9,665,034	106,315,374
SFL AVON	1	18321	66.64	5.923462	3.380488	1.229268293	1000	16,108,390	16,108,390
SINAR BITUNG	2	13596	50.56	2.35099	3.380488	1.229268293	1000	16,108,390	32,216,780

SHIP'S NAME	**Times of Arrival per Year**	**Gross Tonnage**	**Oily Bilge (m3)**	**Sludge (m3)**	**Greywater (m3)**	**Blackwater (m3)**	Price according to GRT (Euro)	Rupiah	per year
SINAR SABANG	38	18321	66.64	3.151865	3.380488	1.229268293	1000	16,108,390	612,118,820
SINAR SUMBA	21	18321	66.64	2.880948	3.380488	1.229268293	1000	16,108,390	338,276,190
SITC SURABAYA	2	27971	85.78	11.9789	3.380488	1.229268293	1600	25,773,424	51,546,848
SONGA HAYDN	1	35981	97.668	5.253817	3.380488	1.229268293	1600	25,773,424	25,773,424
SOUL OF LUCK	3	16915	48.96	3.373569	3.380488	1.229268293	1000	16,108,390	48,325,170
SPECTRUM N	10	26435	82.98	7.708386	3.380488	1.229268293	1600	25,773,424	257,734,240
ST ISLAND	15	27094	83.542	8.426501	3.380488	1.229268293	1600	25,773,424	386,601,360
ST. MARY	5	16900	63.192	2.751266	3.380488	1.229268293	1000	16,108,390	80,541,950
STAR OF LUCK	12	16915	49.752	2.76325	3.380488	1.229268293	1000	16,108,390	193,300,680
TR ARAMIS	2	31370	64.32	8.444862	3.380488	1.229268293	1600	25,773,424	51,546,848
TR ATHOS	5	31370	64.32	12.25579	3.380488	1.229268293	1600	25,773,424	128,867,120
TS TAICHUNG	5	27104	72	5.358224	3.380488	1.229268293	1600	25,773,424	128,867,120
UNI AMPLE	6	14796	43.656	1.98863	3.380488	1.229268293	1000	16,108,390	96,650,340
UNI FORTUNA	7	36483	103.84	6.553979	3.380488	1.229268293	1600	25,773,424	180,413,968
URU BHUM	14	24955	81.16	7.646079	3.380488	1.229268293	1000	16,108,390	225,517,460
VALERIE SCHULTE	9	28927	90.54	4.514727	3.380488	1.229268293	1600	25,773,424	231,960,816
VENETIA	2	42609	120.088	14.83183	3.380488	1.229268293	1600	25,773,424	51,546,848
VICTORIA SCHULTE	1	25406	85.78	3.620885	3.380488	1.229268293	1600	25,773,424	25,773,424
WAN HAI 212	15	17138	44.24	6.162374	3.380488	1.229268293	1000	16,108,390	241,625,850
WAN HAI 216	15	17138	44.24	4.368265	3.380488	1.229268293	1000	16,108,390	241,625,850
WAN HAI 231	5	17751	66.64	6.839783	3.380488	1.229268293	1000	16,108,390	80,541,950

SHIP'S NAME	**Times of Arrival per Year**	**Gross Tonnage**	**Oily Bilge (m3)**	**Sludge (m3)**	**Greywater (m3)**	**Blackwater (m3)**	Price according to GRT (Euro)	Rupiah	per year
WAN HAI 271	3	16776	66.64	5.650256	3.380488	1.229268293	1000	16,108,390	48,325,170
WAN HAI 273	3	16776	63.28	5.673723	3.380488	1.229268293	1000	16,108,390	48,325,170
WAN HAI 281	6	17609	42.36	4.37653	3.380488	1.229268293	1000	16,108,390	96,650,340
WARNOW CHIEF	47	17068	44.48	2.266849	3.380488	1.229268293	1000	16,108,390	757,094,330
WELLINGTON STRAIT	6	18358	66.64	6.92779	3.380488	1.229268293	1000	16,108,390	96,650,340

ATTACHMENT B

OVERALL SYSTEM DESIGN

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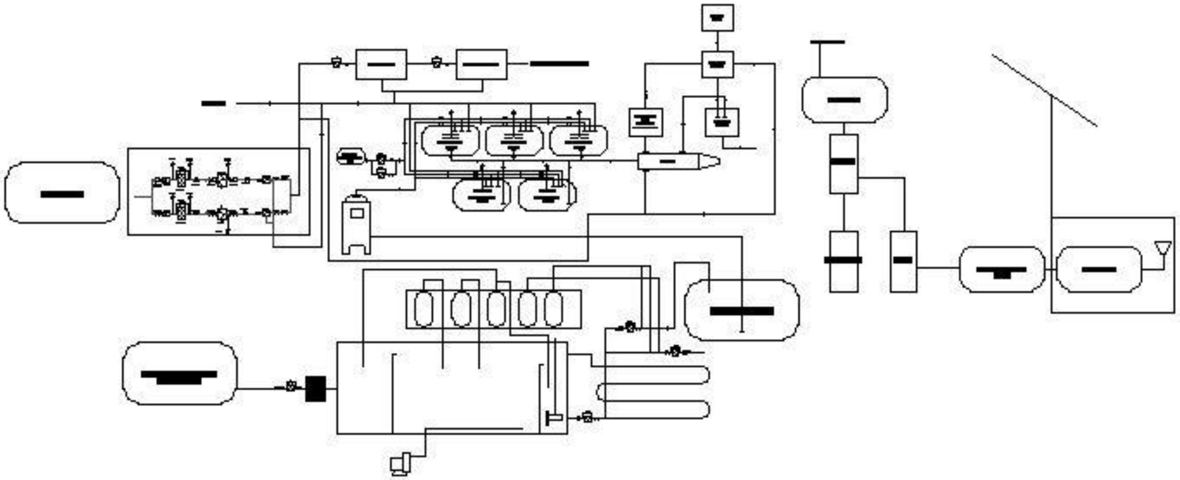

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Centralized WTP

OVERALL SYSTEM

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ATTACHMENT C

LIST OF MAIN EQUIPMENT SPECIFICATIONS

PRODUCT DATA SHEET

Membrane Bioreactor (MBR) Sewage Treatment Plant

water | wastewater | treatment | recycling

OVERVIEW

MAK Water's Membrane Bioreactor (MBR) waste water treatment plants are designed to treat domestic strength sewage, to achieve high quality (Class A+) treated effluent suitable for reuse in non-potable (risk category high) applications.

The standard treatment process involves influent screening, biological degradation (aerobic/anaerobic treatment), Ultrafiltration (UF), with automated chemical cleaning system, and effluent sterilization (chlorination). Additional treatment steps for nutrient removal (T-N & T-P), secondary effluent sterilization (UV), and sludge de-watering systems may be added as required to suit influent quality and/or treated effluent quality requirements. The MAK MBR plants are containerised systems for easy deployment to remote locations.

ADDITIONAL FLOW RATES AND CUSTOMISED SOLUTIONS ARE AVAILABLE. JUST ASK US.

STANDARD SPECIFICATIONS

Parameter	Units	MBR-50	MBR-100	MBR-150	MBR-200	MBR-300	MBR-450	MBR-600
Treatment Capacity	m³/day	50	100	150	200	300	450	600
Sludge Production (WAS)	m³/day	1.5	3	4.5	6	7.5	9	10.5
WAS MLSS	mg/L	8,000–10,000						
Dewatered Sludge (optional)	% solids	15–20%						
Ambient Design Temperature	°C	5–45 (-15–50 for insulated system)						
Power Supply	-	AC 380–450 V, 3 Phase, 50/60 Hz						
Power Consumption	kW	15	30	40	55	80	120	160
No. Containers	-	1 x 20'	1 x 40'	2 x 40'	2 x 40'	3 x 40'	4 x 40'	5 x 40'

Characteristics	Units	Influent	Effluent
Temperature	°C	25–30	-
pH	pH units	6.5–8.5	6.5–8.5
BOD	mg/L	150–300	<10
TSS	mg/L	150–400	<10
T-N	mg/L	<50	<10 (lower T-N available on request)
T-P	mg/L	<15	<10 (lower T-P available on request)
TDS	mg/L	<1,000	-
Turbidity	NTU	-	<2
E.Coli	cfu/100 mL	-	<1
Free Chlorine	mg/L	-	0.2–2
Viruses	% removal	-	99.999

STANDARD INCLUSIONS + OPTIONS

✓ = Standard Supply, o = Optional Supply, – = Not Available

Equipment		MBR-50	MBR-100	MBR-150	MBR-200	MBR-300	MBR-450	MBR-600
MBR Feed Pump		✓	✓	✓	✓	✓	✓	✓
Inlet screen		✓	✓	✓	✓	✓	✓	✓
Anoxic Tank with Mixer		✓	✓	✓	✓	✓	✓	✓
Aerobic Tank with Blower & Diffusers		✓	✓	✓	✓	✓	✓	✓
RAS/WAS Pump		✓	✓	✓	✓	✓	✓	✓
UF Membranes with Feed & Permeate Pumps		✓	✓	✓	✓	✓	✓	✓
UF Backwash & Chemical Cleaning System		✓	✓	✓	✓	✓	✓	✓
Effluent Sterilisation	Flow Paced Hypo Dosing	✓	✓	✓	✓	✓	✓	✓
	Hypo Dosing with Tank Recirculation & Residual Trim	o	o	o	o	o	o	o
	UV Steriliser	o	o	o	o	o	o	o
PLC Control System with HMI		✓	✓	✓	✓	✓	✓	✓
Containerised system, c/w A/C & Lights		✓	✓	✓	✓	✓	✓	✓
UF Container Insulation (walls & ceiling)		o	o	o	o	o	o	o
UF Container non-slip floor coverings		o	o	o	o	o	o	o
UF Container Side Access Door		o	o	✓	✓	✓	✓	✓
Influent Dosing (enhanced T-N / T-P removal)	Sodium Aluminate	✓	✓	✓	✓	✓	✓	✓
	Caustic	o	o	o	o	o	o	o
	Sucrose	o	o	o	o	o	o	o
Sludge Dewatering System (15~20% solids)		o	o	o	o	o	o	o
Premium Instrumentation Package		o	o	✓	✓	✓	✓	✓

Instrumentation	Standard Package	Premium Package
Level Sensors	✓	✓
Pressure Gauges	✓	✓
Pressure Transmitters (4-20 mA)	✓	✓
Magnetic Flow Transmitters (4-20 mA)	✓	✓
Anoxic Tank ORP Analyser	–	✓
Aerobic Tank Dissolved Oxygen Analyser	–	✓
Effluent Chlorine Analyser	–	✓
Effluent Turbidity Analyser	–	✓
Effluent pH Analyser	–	✓
Remote Monitoring & Control Capabilities	–	✓

MODEL SELECTION

NEED A QUOTE?

COMPLETE THIS TABLE AND EMAIL TO...

sales@makwater.com.au

0050 50 m³/day
0100 100 m³/day
0150 150 m³/day
0200 200 m³/day
0300 300 m³/day
0450 450 m³/day
0600 600 m³/day

X Containerised Plant, standard supply
F Containerised Plant with floor coatings
P Containerised Plant with floor coatings & insulation

X Effluent Sterilisation - Flow paced hypo dosing, standard supply
H Effluent Sterilisation - Hypo dosing with tank recirculation & residual trim
U Effluent Sterilisation - UV
D Effluent Sterilisation - UV + hypo dosing with tank recirculation & residual trim

X Influent Dosing Systems - Standard supply
C Influent Dosing Systems - Custom (specify caustic/sodium aluminate/sucrose)

X Standard instrument package
P Premium instrumentation package, c/w remote monitoring
C Custom supply

X Sludge dewatering - Without
S Sludge dewatering - With

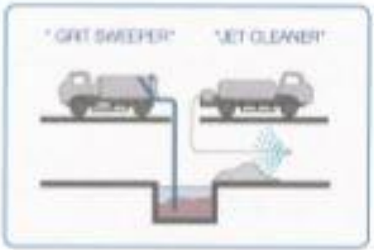
MBR: _ _ _ _ _ _ _ _ _

Disclaimer: MAK Water is continuously updating and improving its products and services, so please contact us for more detailed information or to confirm specifications. MAK Water takes no responsibility for any errors resulting from the use of information contained within this document.

ShinMaywa

HIGH PRESSURE GULLY CLEANER
JET CLEANER
SEWERAGE CLEANING SYSTEM

JET CLEANER is a vehicle equipped with device to forcibly wash is retro-jettisoned from the nozzle attached at the tip of the hose proceeding into sewer pipe.



*Photographs on this catalog may include optional equipment and may differ from the vehicle delivered.

■Features

- ●High pressure plunger pump is equipped.
- ●Automatic cleaning operation and efficient sanitary operation
- ●Apply for cleaning chemical plant pipe.

Hose reel can be manually positioned in suitable direction within 180 degrees by a slewing gear.

▲Control panel

■Standard accessories

JET CLEANER

■Specifications

Model		GJ040-060M	GJ050-060M	GJ080-060M	GJ100-060M
Tank Capacity		3,300L	4,300L	7,200L	10,500L
High Pressure Water Pump	Make & Model	URACA KD718G			
	Max capacity	240L/min at 1,867rpm			
	Max pressure	20MPa (204kgf/cm²)			
	Type	Plunger pump			

The above mentioned figures are approximate.

* Optional equipment are included in these photographs.
* Specifications and dimensions are subject to change without notice.

ShinMaywa Industries, Ltd.

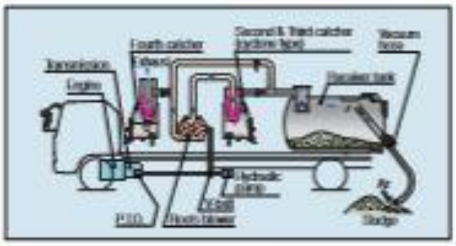
International Sales Dept.
Special Purpose Truck Div.
3-2-43, Shiohe, Tsurumi-ku, Yokohama, 230-0003, Japan
Telephone : +81-45-575-6163
Facsimile : +81-45-575-9837
e-mail : overseas@shinmaywa.co.jp

http://www.shinmaywa.co.jp

Printed on recycled paper.
'15. 9 Z-E067E Printed in Japan

CLEAN CUUM

CLEAN CUUM has powerful vacuum pump with strong air flow which is very efficient for suction at deeper and long distance.



Specifications

Model		GV4-W201C	GV7-W201C	GV11-W201C
Tank full volume		3,200L	5,900L	10,500L
Vacuum system		Roots blower		
Vacuum capacity	Max.air volume	$24m^3/min$		
	Max.vacuum	-93kPa [-700mmHg]		
	Max.pressure	59kPa [$0.6kgf/cm^2$]		
	Dry sand	5,000kg/hour		
	Sewage	15,000kg/hour		
Required PTO torque		294N·m [30kgf·m] or more	343N·m [35kgf·m] or more	490N·m [50kgf·m] or more
Suitable chassis GVW		8,000~9,000kg	14,000~15,500kg	22,000~29,000kg

The above mentioned figures are approximate.

∗Optional equipment are included in these photographs.
∗Specifications and dimensions are subject to change without notice.

ShinMaywa Industries, Ltd.

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Special Purpose Truck Div.
3-2-43, Shitte, Tsurumi-ku, Yokohama, 230-0003, Japan
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e-mail : overseas@shinmaywa.co.jp

http://www.shinmaywa.co.jp

'14.9 Z-E088D
Printed on recycled paper.

	Standard	Metric
Year	2014	
Serial Number	SMP14-5-30138	
Capacity of Tank	10000 Lm	10000 Lm
Tank Material of Construction	STAINLESS STEEL	
Internal Pressure Rating	14.7 PSI	14.7 PSI
Internal Temperature Rating	100 DEG C	100 DEG C
Jacketed	YES	
Jacket Pressure Rating	5 BAR	5 BAR
Jacket Temperature Rating	75 DEG C	75 DEG C
Agitation	YES	
Inside Diameter	2100 MMG	2100 MMG
Overall Height	4500 MMG	4500 MMG
Straight Side	1 MMG	1 MMG
Estimated Shipping Weight	11178 lb	5070 KGS
Model	VS-8040	
Phase	3	
Estimated Shipping Length	2620 IN	66548 mm
Estimated Shipping Width	2100 IN6	2100 IN6
Estimated Shipping Height	4500 IN	114300 mm

BOILER SPECIFICATION		
Boiler Type	NG-35/3.82-M5	
Drawing number	87225	
Steam Output	t/h	35
Superheated steam pressure	MPa	3.82
Superheated steam temperature	℃	450
Preheated air temperature	℃	158
Feed water temperature	℃	150
Fluidizing bed temperature	℃	962
Cross section velocity	Nm/s	3.66
Coal-sludge water content	%	25
Coal-sludge low heat value	Kcal/kg.	2955
Coal-sludge water content	%	25
Thermal strength of cross section	W/m2	2260000
Exhaust gas temperature	℃	167.7
Combustion efficiency	%	92
Boiler thermal efficiency	%	80.7
Gas pressure drop	KPa	0.81
Overall metal weight	t	142.4
Max. shipping weight	t	12.75
Overall dimension (LxWxH)	m	9x5.8x17

Quick Details

Place of Origin:	Shandong, China (Mainland)	Brand Name:	Better
Model Number:	LDF	Type:	Incinerator
After-sales Service ...	Video technical support, Field installation, commissioning an...	Warranty:	1 Year
Color:	Silver/ Blue	Capacity:	20-500kgs/batch
Material:	carbon steel/ SUS304/316	Application:	Hospital/Farm/Household (sol

Supply Ability

Supply Ability:	100 Set/Sets per Month

Quick Details

Condition:	New	Flow:	55-200 L/Min
Place of Origin:	Chongqing, China (Mainland)	Brand Name:	Ziguan
Voltage:	220~415V	Power(W):	12-24KW
Dimension(L*W*H):	238*150*210 CM	Weight:	2000KGS
Certification:	CE/ISO	Warranty:	1 Year
After-sales Service ...	Field maintenance and repair service, Engineers available to s...	Color:	Green
Function:	Waste Oil Recycling	Material:	Cabon Steel
Capacity:	2-50TONS		

Supply Ability

Supply Ability: 20 Set/Sets per Month

Packaging & Delivery

Packaging Details 1 set in a wooden case

Port shanghai port

Lead Time ?:

Quantity(Sets)	1 - 1	>1
Est. Time(day)	15	To be negotiated

KD Mechanical diaphragm dosing pump

1. Voltage : 110v-240v single phase, 220v-440v three phase.
2. Flow rate: 15-180 L/H, pressure: 5-8 bar, power: 0.18kw
3. Material: PVC, PTFE, SS304, SS316.
4. Hyperlink: Detail informations about KD dosing pump

Quick Details

Place of Origin:	Hubei, China (Mainland)	Brand Name:	Meir Heng
Model Number:	KD	Structure:	Diaphragm Pump
Usage:	Chemical, Flocculant, water	Application:	Chemical, Flocculant, water
Power:	Electric	Fuel:	Electric
Pressure:	Low Pressure	Frequency:	50 /60 Hz
Voltage:	110V~240V single phase, 220V~440V three phase	Casing material:	PVC, PTFE, SS304, SS316
Warranty of pump:	12 months	Warranty of quick-...	3 months
Packing:	Plywood Case	Standard or Nonsta...	Standard
Theory:	Metering Pump		

Supply Ability

Supply Ability:	100 Set/Sets per Month The stock is available

Packaging & Delivery

Packaging Details	Plywood case (or as customer's demands)
Port	Ningbo, Shanghai, Shenzhen
Lead Time ?:	Shipped in 20 days after payment

Quick Details

Condition:	New	Type:	Gravity Separator
Production Capacity:	98%	Place of Origin:	Jiangxi, China (Mainland)
Brand Name:	Henghong	Model Number:	STLB
Voltage:	220V/380V	Power(W):	0.75-18.5kw
Dimension(L*W*H):	Depend on the model	Weight:	145-2000kg
Certification:	CE, ISO9001, SGS	Product name:	Gravimetric falcon centrifugal concentrator
Feeding size:	0-6mm	Capacity:	0.2-120t/h
Feeding density:	10-50%	Backwash Water:	1.5-60t/h
Color:	As required	After sale service:	The whole using life
Installation:	Technical guidance	Price:	Negotiable
Centrifugal concen...	Have in stock	Warranty:	1 Year
After-sales Service ...	Engineers available to service machinery overseas		