DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCE

WASTE MANAGEMENT AND EVALUATION OF CARBON FOOTPRINT IN HARBOURS

by
Yiğit PEHLİVAN

October, 2016
İZMİR

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A Thesis Submitted to the Graduate School of Natural and Applied Sciences of Dokuz Eylül University In Partial Fulfillment of the Requirements for the Degree of Master of Science in Environmental Engineering

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İZMİR

M.Sc THESIS EXAMINATION RESULT FORM

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WASTE MANAGEMENT AND EVALUATION OF CARBON FOOTPRINT IN HARBOURS

ABSTRACT

Environmental pollution and waste management are getting important because of industrial development, increasing population and unplanned urbanization. In these days we are going through, natural sources come to an end rapidly and because of that waste management planning and implementation become obligotary. Improvements about these subjects work when it is supported by law.

In recent years, air pollution has an increasing rate. Because of that application of measurement and control is getting important. Global warming and greenhouse effect are terms which were entered our lives recently and they are popular. For this reason, there are many scientific study about these terms.

In this study mention to environmental effects of harbours and ports. What kind of waste is given, amount of wastes, their disposal processes were studied. Besides, international and national regulations about ports and harbors waste management applications were scrutinized.

In this study, carbon footprint that was entered our lives with global warming and greenhouse effect were analyzed. Especially for ports and harbours, emission sources and their amounts was determined and carbon footprint of ships was calculated.

Keywords: Waste management, waste management in ports and harbours, emission, carbon footprint in ports and harbours.

LİMAN İŞLETMELERİNDE ATIK YÖNETİMİ VE KARBON AYAK İZİNİN İNCELENMESİ

ÖZ

Endüstrinin gelişimi, popülasyonun artışı, plansız şehirleşme gibi sebepler, çevre kirliliği ve atıkların yönetimi konularını önemli kılmaktadır. Doğal kaynakların hızla tükendiği bu günlerde, atık yönetimi planlaması, uygulanması zorunlu hale gelmiştir. Bu konudaki iyileşmeler yasalarla desteklendiğinde iyi sonuç vermektedir.

Hava kirliliği de son yıllarda oldukça artan bir grafik sergilemektedir. Bu da hava kirliliği ölçüm ve kontrol mekanizmalarını önemli hale getirmektedir. Küresel ısınma, sera etkisi gibi kavramlar son yıllarda hayatımıza girmiş ve popüler hale gelmşlerdir. Bu sebeple, bu kavramlar üzerinde bir çok bilimsel çalışma yapılmaktadır.

Bu çalışmada limanların çevresel etkilerine değinilmiştir. Limanlardan ne tür atıklar çıktığı, miktarları, bertaraf yöntemleri gibi konular incelenmiştir. Ayrıca limanlarda atık yönetimi ile ilgili uluslararası ve ulusal yasal düzenlemeler üzerinde durulmuş, atık yönetimi uygulamaları detaylı bir şekilde incelenmiştir.

Bu çalışmada küresel ısınma ve sera etkisi gibi kavramlarla birlikte hayatımıza giren karbon ayak izi kavramına değinilmiştir. Limanlar özelinde emisyon kaynakları, emisyon miktarları ve bu kaynaklardan biri olan gemiler için karbon ayak izi hesaplamaları yapılmıştır.

Anahtar Kelimeler: Atık yönetimi, limanlarda atık yönetimi, emisyon, karbon ayak izi, limanlarda karbon ayak izi.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

Waste management is getting important nowadays. Especially because of decreasing natural sources, increasing population and unplanned urbanization, wastes from every sources have to be managed well. International and national laws about environment enforce waste management and reducing wastes.

Global warming and air pollution is increasing recently. Industrilization is the main cause of them. Every authority start thinking how to reduce carbon emissions. Several protocols have been made for it. These protocols and again international and national regulations are stricter in these days. Every country tries to reduce their carbon emissions. The terms of carbon footprint show up and is getting important every day. To reduce carbon emission, people realise that emission inventory has to be made and after that carbon footprint has to be calculated.

1.2 Aim and Scope of the Study

Aim of the study is research about waste management in ports and harbours, analyzing and calculating carbon footprint of ports and harbours. Waste management of port and harbour operations are explained in chapter two. Detailed informations about waste management of port and harbours which are waste types, amount of wastes, their disposal process, environmental obligations accordint to international and national regulations were given and analayzed them in this chapter. In third chapter meaning of carbon footprint of ports and harbours, its applications and calculations were examinated in detail.

The purpose of the study is analyzing waste management and applications in port and harbours and also researching about carbon footprint, its measurements and calculations in ports and harbours.

CHAPTER TWO
WASTE MANAGEMENT IN HARBOURS

The protection of the world's oceans from pollution is an environmental issue of immense international concern. By analysing the actual individual samples, it has been deduced that merchant shipping accounts for 15-35% of the total waste. It has also been estimated that 65% of waste came from fishery vessels. Oil is the most widely publicised and studied form of pollution from shipping which is estimated to contribute approximately 45% of the total anthropogenic oil inputs into the marine environment (Palabıyık, 2003).

Waste management and its implementation is very important issue for environmental sustainability, economical development. Port and harbour waste management and its implications form a rapidly growing subject of interest in the city management context. Because harbours are sources of considerable volumes of valuable wastes, one of the main subjects of local authorities dealing with urban sustainable development matters is ship and port waste management. However, according to the related national and international regulations ports expose good examples as the best examples of practices for sustainable waste management efforts within their distinct determined jurisdictions (Palabıyık, 2003).

Waste management from ships is covered in the Internatıonal Health Regulations (IHR) 2005 and in more detail in the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78, as amended). MARPOL was adopted by the International Conference on Marine Pollution in 1973 and has been subject to numerous amendments as it is updated, including the 1978 protocol and amendments collated into a consolidated version in 2002 (World Health Organization (WHO), 2011).

The International Convention for the Prevention of Pollution from Ships 1973, and its 1978 Protocol (MARPOL 73/78) aims to regulate and minimise pollution from

ships. MARPOL 73/78 covers the five main forms of ship generated waste in five specific annexes which are summarised in Table 2.1

Table 2.1 MARPOL regulations relating to reception facilities (Associated British Ports (ABP), 2014)

Annex	Category of waste	Annex in force	Reception facilities required	Types of waste for reception
I	Oil	2nd October 1983	✓	Covers all types of wastes from the carriage of oil: As fuel, engine room slops, cargo (tank washings) or dirty ballast water
II	Noxious liquid substances in bulk	6th April 1987	✓	Chemical wastes derived from bulk chemical transportation, including residues and ixtures containing noxious substances
III	Harmful substances carried by sea in packaged form	1st July 1992	X When annex comes into force	-
IV	Sewage from ships	X	✓	Raw sewage-retained in holding tanks for disposal in port or outside 12 nm Partially treated sewage-retained in holding tanks for disposal in port or outside 4 nm
V	Garbage from ships	31st December 1998	✓	Garbage includes domestic (food and packaging) and operational (maintenance, cargo and miscellaneous) wastes
VI	Air pollution from ships	19th May 2005	X When annex comes into force	-

A series of annexes (I - V) cover pollution by oil, noxious liquids, harmful substances in packaged form, sewage and garbage. Annex VI, which has been adopted recently, aims at extending the regulations to cover air pollution from ships. These regulations have been developed over a number of years and are in place, but there is significant concern over their real workability. MARPOL Regulations for the provision of reception facilities for ship generated waste are installed in national legislation. These national regulations require port authorities and terminal operators to provide reception facilities for ships which are using the port or terminals in general. However, the facilities must be adequate to meet the needs of ships using them without causing them undue delay (ABP, 2014).

2.1 Ship Generated Waste Types

There are several type of waste generated by ships. These can be listed as below:

1. Bilge water
2. Sludge
3. Waste oil
4. Garbage
5. Hazardous wastes
6. Waste water

Bilge is compartments where leaking water and oily wastewaters from machine and auxiliary undertanks, cofferdams, repositories and similar compartments of ships accumulate, and bilge water is liquids accumulating in the bilge (Official Gazette, 26 December 2014 No:25682).

Sludge is mud formed from deposits and/or oil sediments in the engine rooms, fuel tanks of ships or cargo tanks of petroleum tankers (Official Gazette, 26 December 2014 No:25682).

Waste oil is changed oil from engines. When engines oil is needed to be changed waste oil occur.

Garbage is domestic waste which includes food, biodegradable waste, and unharmful wastes.

Hazardous waste includes toxic substances and destructive to the environment. Hazardous wastes can be very dangerous all kind of livings.

Ships generates waste water because of crew. Waste water comes from toilets, showers, kitchen etc. and accumulate in waste water tank. It is given to waste reception facility when ship come into port.

2.2 Range of Ships and Ship Generated Wastes

Ports and harbours serve the purpose of storage, warehousing, shiping and unshiping of export and import commodities. Cargo ships, container ships, passenger ships, dry cargo ships, dry or wet bulk carriers come into ports and harbours in accordance with this purpose. In Table 2.2 amount of ships that came into port is shown. These informations was get as a result of personal experiences.

Table 2.2 An example of amount of ships that come into port

Months	Number of Ships	Number of Ships That Give Waste	Amount of Waste				
			Bilge Water (m^3)	Sludge (m^3)	Waste Oil m^3)	Waste Water (m^3)	Garbage (m^3)
December	137	38	20.17	105.81	0.9	0	64.8
November	142	55	47.7	217.3	4.36	0	350.26
October	125	66	102.1	157.85	0.45	0	435.06
September	124	73	122.65	171.06	1	4	681.75
August	128	71	97.36	136.63	0	0	655.69
July	113	68	58.4	143.4	2	1	683.27
June	83	69	23.1	69.5	0	0	416.38
May	142	66	45.7	145.1	0	0	647.74
April	135	56	23	44.03	0	0	297.27
March	141	49	14.1	7.5	0	1	300.4
February	118	44	0.8	8.3	0	0	165.5
January	146	65	9.5	12.5	0.5	2	216.3
Total	**1534**	**720**	**564.58**	**1218.98**	**9.21**	**8.00**	**4914.42**

Table 2.2 gives us some information about ships that come into port and generated wastes by them. Foregoing table shows us number of ships that come into ports, how many of them gave waste, what kind of wastes that gives and amount of given wastes.

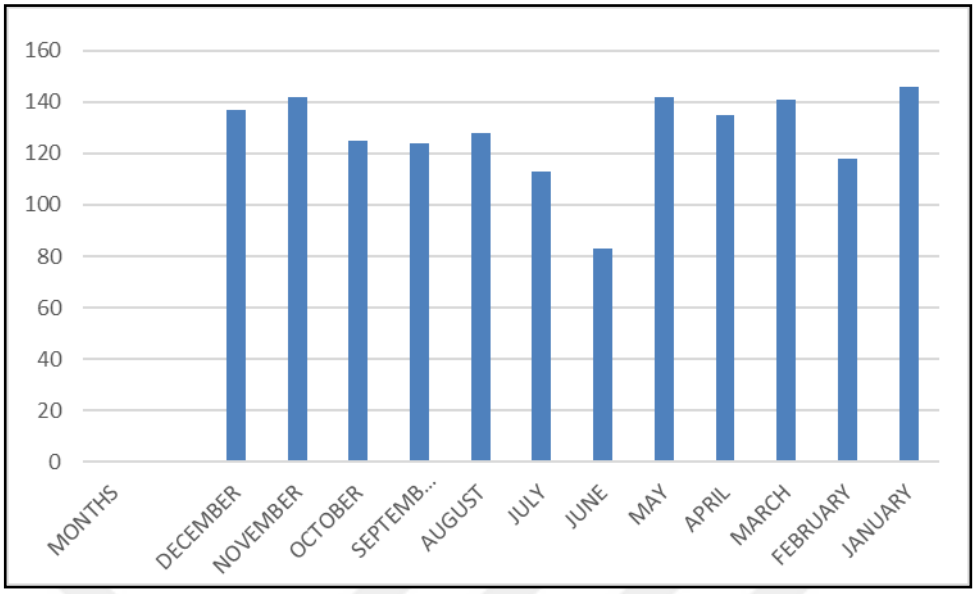

Figure 2.1 Number of ships came into port

Figure 2.1 shows that number of ships which came into port distribution by months. There isn't big difference between amounts of ships. Almost every month number of ships that approach the port are the same.

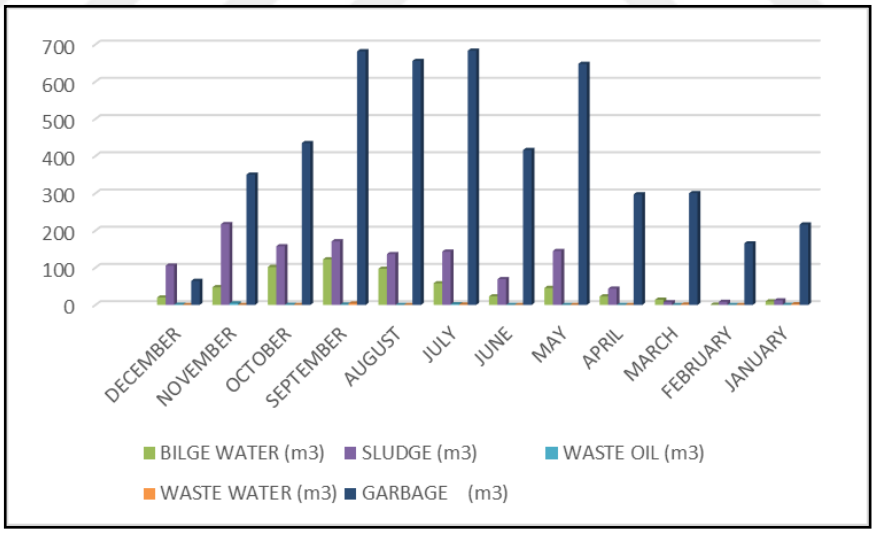

Figure 2.2 Distrubution of wastes by months

Waste amounts are different for each month. As it is seen from Figure 2.2 garbage amount that is given increase in summer. However, season that has most large amount of sludge is fall. Winter is the season which has minimum waste amount.

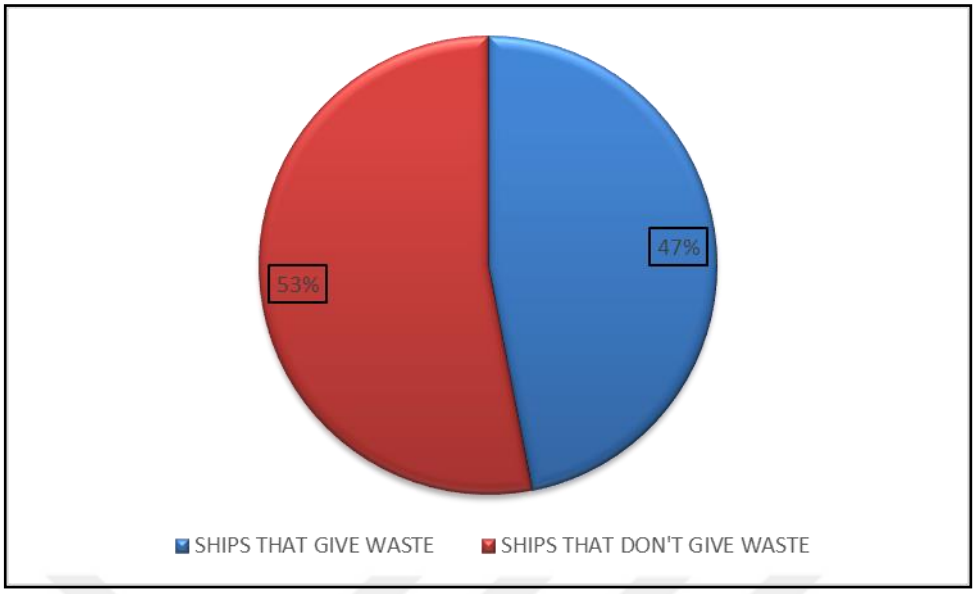

Figure 2.3 Ratio of ships that give waste

According to Table 2.2, 1534 ships approach the port and 720 of them gave wastes. That means %47 of total ships gave wastes when they approached the port.

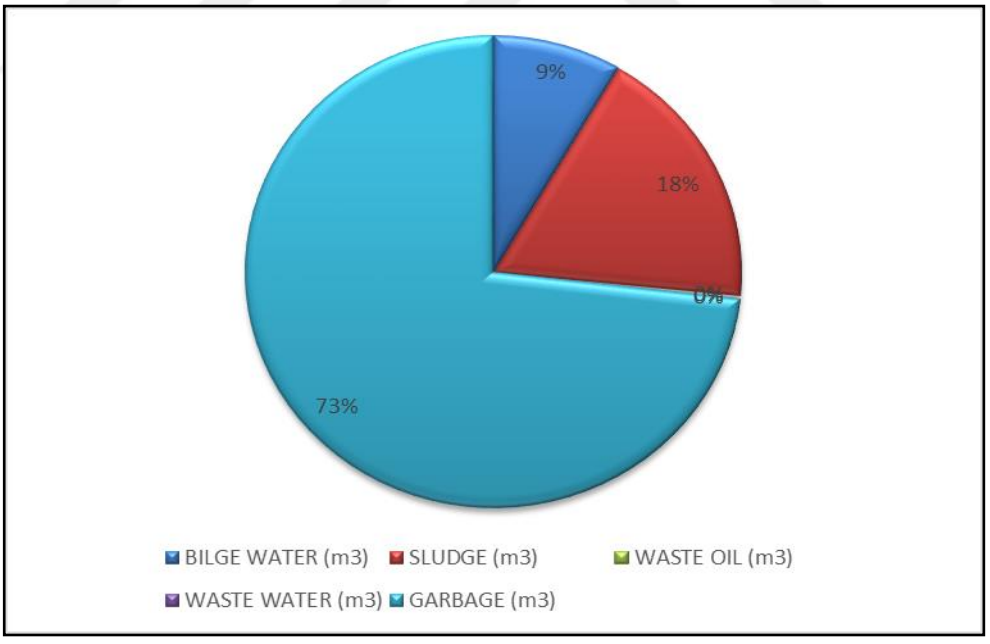

Figure 2.4 Ratio of wastes

Figure 2.4 is about percentage distrubition of wastes which are given by ships that is came into port. When we look at the Figure 2.4 we can say that garbage is the most generated and removed waste kind and its ratio is %73 of all wastes. Second large

amount of waste is sludge which its ratio is %18. Third one is bilge water which is hazardous waste kind with %9 percentage. Waste water's and waste oil's percentages are not worth the consider because they are under %1.

2.3 Disposal of Ship Generated Wastes

According to regulation about waste management of harbours and ports, waste reception facility must be built to dispose ship generated wastes. Waste reception facilities are the first step of waste disposal process. There are several steps of waste disposal from harbours and ports. Every kind of waste generated by ships have its own process to dispose.

Amount and type of wastes from ships that are entered in harbour determine and report to Harbour Management. After that, wastes are taken with waste transfer form by authorized person of waste reception facility.

Wastes like bilge water and sludge are loaded in tanks of waste reception facility. Wastes like garbage and packing wastes are separated and collected in solid waste storage area.

Bilge water that was taken from the waste reception facility are sent to separator. After the separation process two kind of wastes accure as bilge water oil and waste water. Waste water are treated by chemical treatment system and are discharged.

According to national regulations bilge water and sludge are hazardous wastes. Because of that to dispose these wastes set up a commission. And they send to licenced facility to dispose.

2.3.1 Disposal Process of Bilge Water

Bilge water is generated by ship engine or cooling system of engine. It is a mixture of sea water, fresh water, oil, sludge and various other liquids. It is collected a tank that is located in base of the ship. (Bright Hub Engineering (BHE), 2016)

Ships reports their wastes on waste tracking system of Ministry of environment and Urbanisation. After ship enter the harbour, authorized people of waste reception facility go to the ship in 1 hour maximum. Bilge water is taken by tanker and sent to the waste reception facility. Bilge water handed by tanker to facility is loaded in bilge water tank of waste reception facility. Authorized people prepare a waste transfer form for each ship and after finish the operation enter the ship waste tracking system.

Bilge water was taken are separated as waste water and oil. The Commission decide that time of disposal. Wastes are sent with licenced transporter to licenced disposal facility. According to personal experiences flow process of bilge water is shown in Figure 2.5.

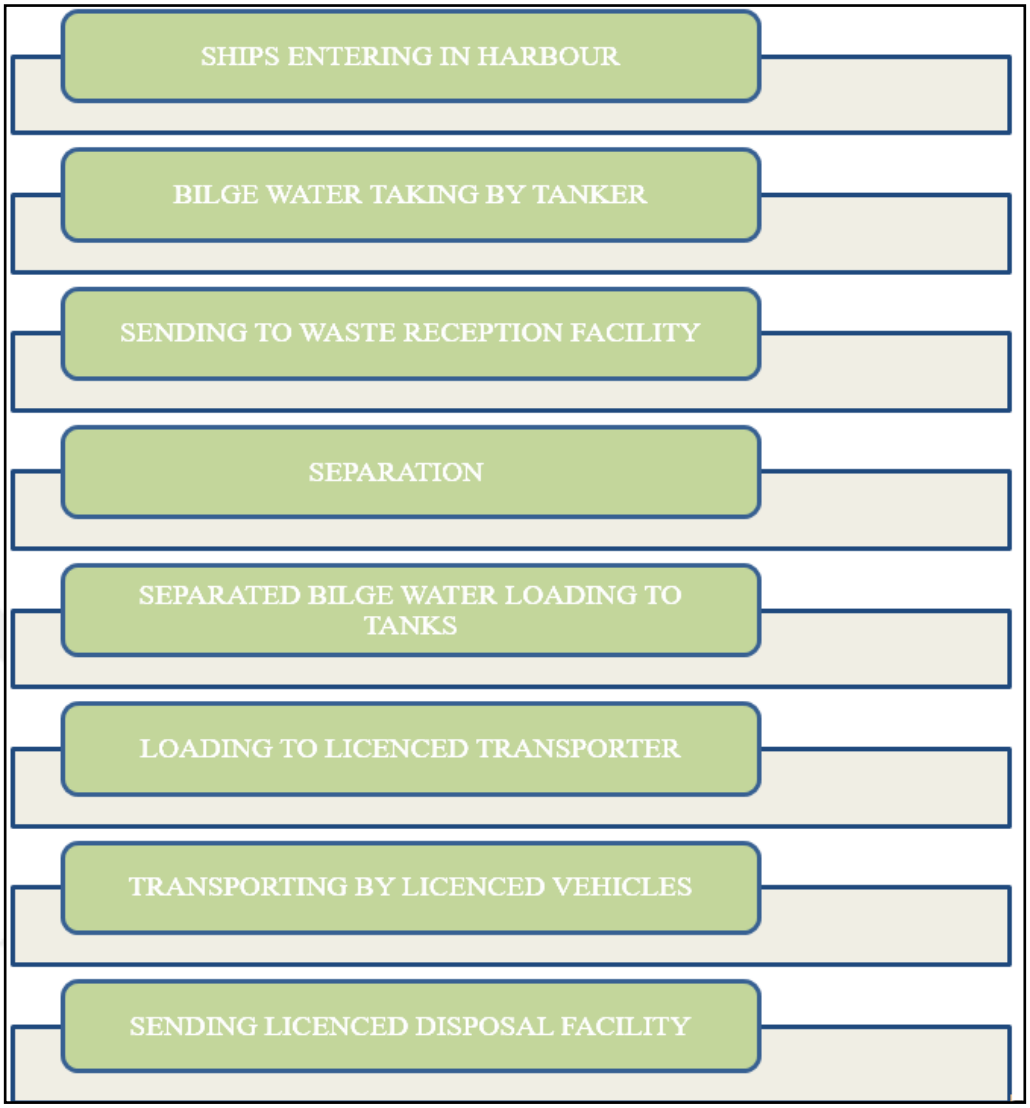

Figure 2.5 Flow process chart of disposal of bilge water

2.3.2 Disposal Process of Sludge

The heavy part of ship's fuel which is incombustible is collected as sludge. Ships that use heavy fuel oil collect %1-2 of their daily fuel oil, others collect %0,5 of their daily fuel oil as sludge. Generally, ships have sludge tanks which have 5-10 tones capacity. After 15-20 day navigation, tanks will be full. Sludge is high viscosity matter and it can turn into liquid form when it is heated (Officer of the Watch, 2016).

Ships reports their wastes on waste tracking system of Ministry of Environment and Urbanisation. After ship enter the harbor, authorized people of waste reception

facility go to the ship in 1 hour maximum. Sludge is taken by tanker and send to the waste reception facility. Sludge handed by tanker to facility is loaded in sludge tank of waste reception facility. Authorized people prepare a waste transfer form for each ship and after finish the operation enter the ship waste tracking system.

There isn't any special process for collected sludge. It is collected in sludge tank of waste reception facility. The Commission decide that time of disposal. Wastes are sent with licenced transporter to licenced disposal facility. According to personal experiences flow process of sludge is shown in Figure 2.6.

Figure 2.6 Flow process chart of disposal of sludge

2.3.3 Disposal Process of Waste Oil

Waste oil occur when machine's oil is changed in ships. Waste oil amount show an alteration according to size of ships.

Ships reports their wastes on waste tracking system of Ministry of Environment and Urbanisation. After ship enter the harbor, authorized people of waste reception facility go to the ship in 1 hour maximum. Waste oil is taken by tanker and send to the waste reception facility. Waste oil handed by tanker to facility is loaded in waste oil tank of waste reception facility. Authorized people prepare a waste transfer form for each ship and after finish the operation enter the ship waste tracking system.

Waste oil hasn't water. Because of that, there is no need to separation process. Waste oil that is collected in waste oil tank of waste reception facility send to licenced disposal facility with licenced transporter. The Commission decide how and when is disposal. According to personal experiences flow process of waste oil is shown in Figure 2.7.

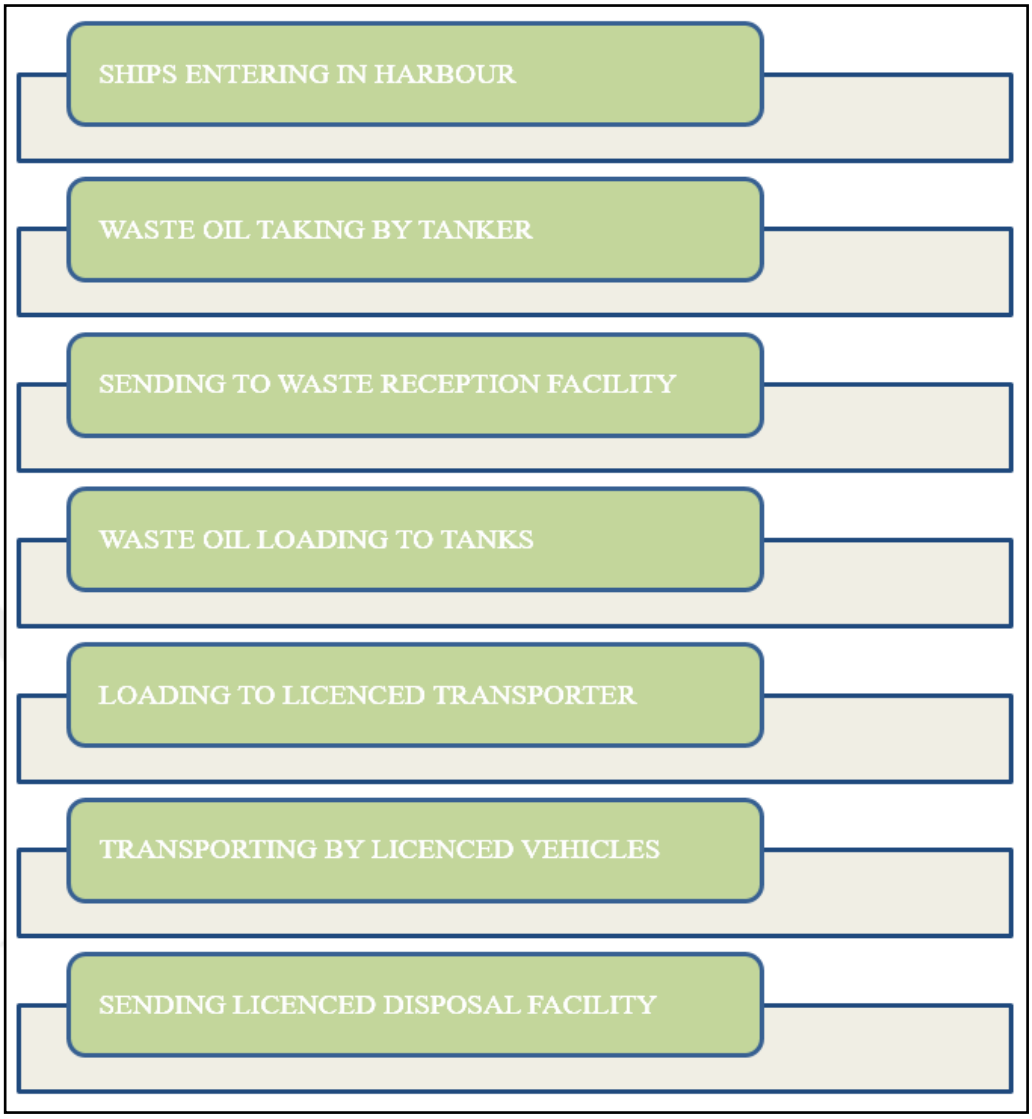

Figure 2.7 Flow process chart of disposal of waste oil

2.3.4 Disposal Process of Garbage

Garbage means domestic waste which include food wastes, biodegradable wastes, packing wastes and nonhazardous wastes.

Generally, one person generates about 1.5 kg garbage per day in ship. Garbage generated by ships generally include biodegradable and packing wastes. Packing wastes is separated from biodegradable wastes. Because, packing wastes are recyclable (Cantin, J. & Eyraud, J. & Fenton, J. (n.d)).

Garbage is taken from ships and send to waste collection area. Garbage that is collected periodically send to city land fill. According to personal experiences flow process of garbage is shown in Figure 2.8.

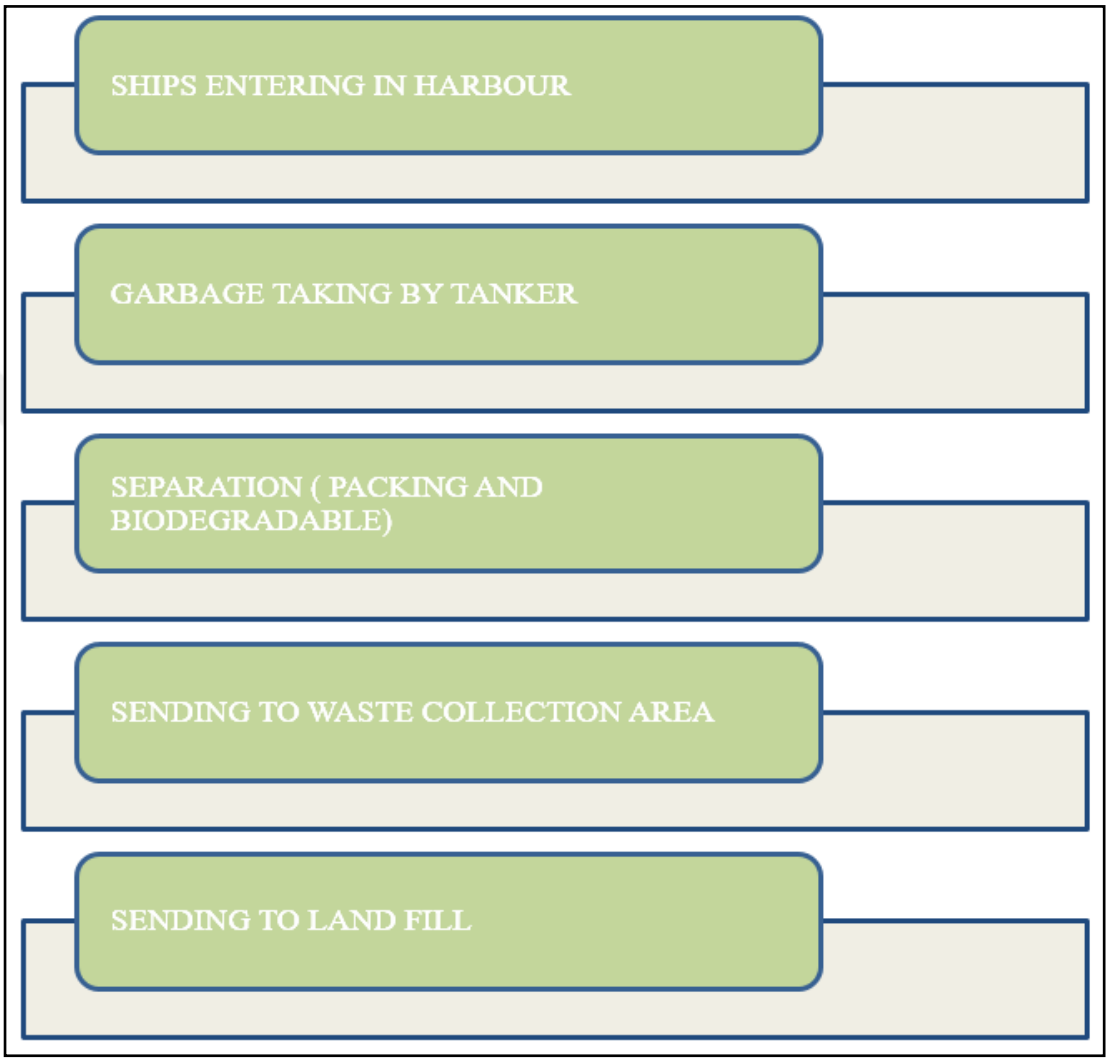

Figure 2.8 Flow process chart of disposal of garbage

2.3.5 Disposal Process of Hazardous Wastes

A hazardous waste is a waste with a chemical composition or other properties that make it capable of causing illness, death, or some other harm to humans and other life forms when mismanaged or released into the environment (California Department of Toxic Substances Control, 2010).

Ship generated hazardous wastes can include contaminated cloth, barrel contaminated with chemical matter etc. This kind of wastes are taken from ships and send to hazardous waste collection area. Like bilge water and sludge, hazardous wastes sent with licenced transporter to licenced disposal facility.

According to Regulation of Waste Management that was published on Official Gazette, in 02 April 2015 numbered 29314, hazardous wastes can be wait 6 month maximum. Maximum 6 months later hazardous wastes have to be sent to licensed disposal facility. According to personal experiences flow process of garbage is shown in Figure 2.9.

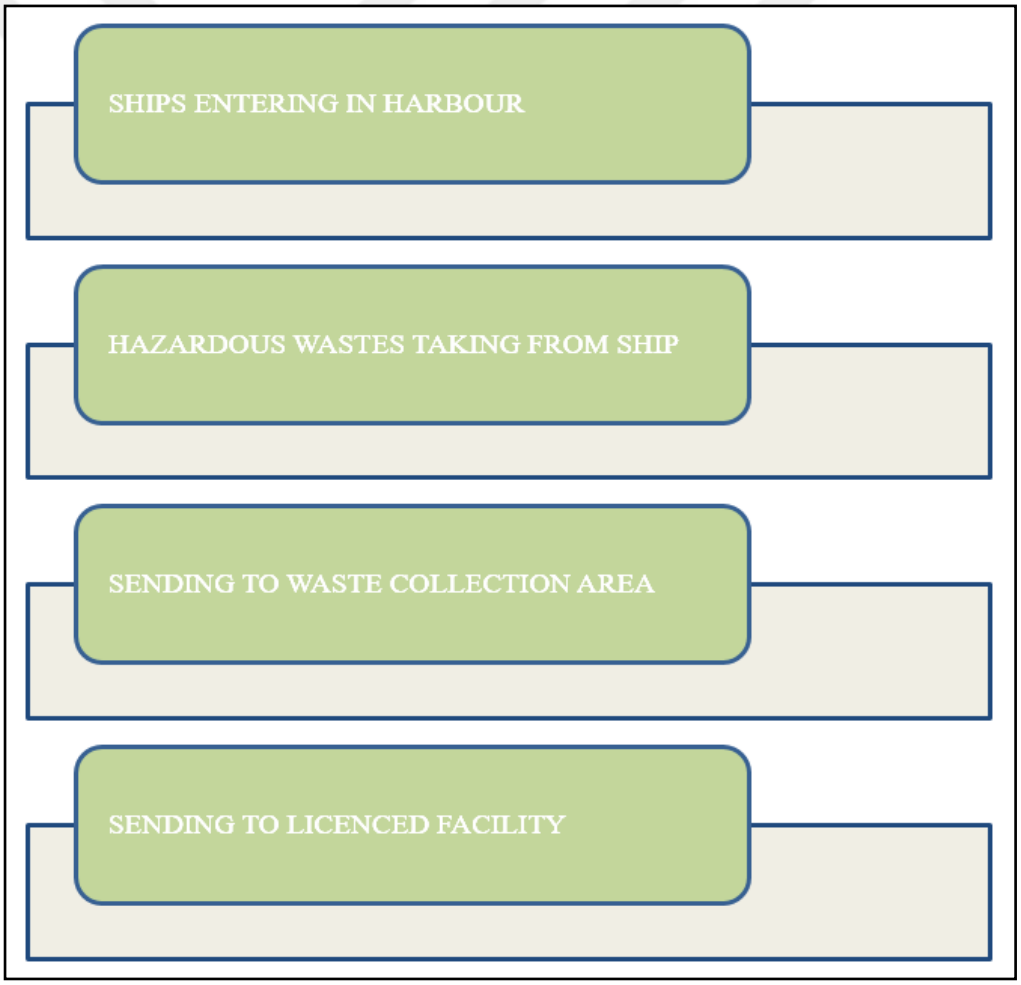

Figure 2.9 Flow process chart of disposal of hazardous wastes

2.3.6 Disposal Process of Waste Water

Waste water is generated by crew of ships. Toilet, shower and kitchen are main source of waste water in ships. Waste water that is generated by crew accumulate in waste water tank in ship. It can be remove when ships come into port. Ships give it to waste reception facility of port. Waste water is taken by tanker from the ship. After that it is discharged into sewage of city. Disposal process of waste water is shown in Figure 2.10.

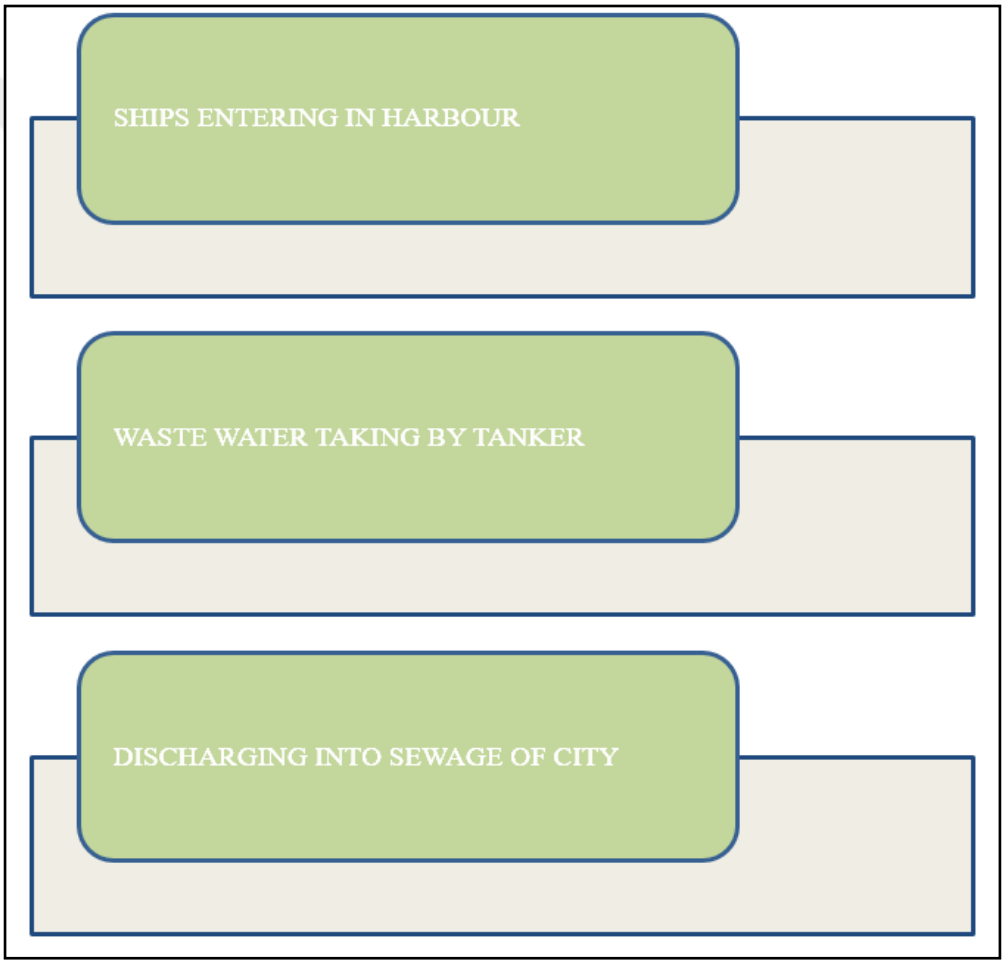

Figure 2.10 Flow process chart of disposal of waste water

2.3.7 Waste Transfer Form

According to Regulation of Reception of Wastes from Ships and Waste Control that is published on 18 March 2010 dated and 27525 numbered, port management has some obligation which are as the following:

- To receive wastes that is generated by ships which are came into port or waiting off according to regulations without causing any delay
- To dispose wastes which are accumulated in waste reception facility of the port management according to Environmental Law
- To obtain permit from Ministry of Environmental and Urbanization about wastes which are generated by ships and not defined in regulation that may toxic, hazardous, chemical, infect disease etc.
- To organize waste transfer form for ships and make notification to Provincial Department of Environment.
-

There is second step of waste disposal which is generated by ships. Wastes are taken by authorized person of waste reception facility and then they have to send to licenced disposal facility. In this subject there are some obligation for waste reception facility and the port management which are as following:

- To collect wastes according to their type and storage temporary
- To permit from Provincial Department of Environment about temporary storage area.
- To sent wastes to waste disposal facilitiy which have been licenced according to regulations of Ministry of Environment and Urbanization.

To send wastes which have to be disposed with National Waste Transfer Form to licenced disposal facility with National Waste Transfer Form. These forms are shown in Figure 2.11 and Figure 2.12.

Form No

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT AND FORESTRY
TRANSFER FORM FOR SHIP-GENERATED WASTES

1-WASTE GIVING SHIP / TANKER		
Flag:	Line of Activity:	
IMO Number:	Waste Code (2):	
Name of the Proprietor / Company:	Waste Type (2):	
Company Address:	Weight: ……tons .....kg-lt	
	Other Annexed Details:	
Phone No:	Packaging Type (3):	
Fax No:	Number of Packages:	
Name of its agency in our country:	Waste Transfer Date:	
Address of its agency in our country:	Waste Transfer Start Time:	
	Waste Transfer End Time:	
Phone No:	Of the current location of the ship	Name: Coordinates:
Fax No:		
BM class (1): H Number (1):	**Person in Charge of the Ship / Tanker**	
	Name : **Title :** **Signature :**	
2-WASTE RECEPTION SHIP		
Port authority zone it is affiliated to		Waste Transfer Date:
		Waste Transfer Start Time:
Licence No:		Waste Transfer End Time:
Name of the Proprietor / Company:	**Person in Charge of the Waste Reception Ship**	
Phone No:	**Name :**	
Fax No:	**Title :**	
	Signature :	
3-WASTE RECEPTION FACILITY		
Name of the port it is located:	Waste Transfer Date:	
Address of the port it is located:	Waste Transfer Start Time:	
Licence No:	Waste Transfer End Time:	
Phone No:	**Person in Charge of the Waste Reception Facility**	
Fax No:	**Name :**	
Number of the depot where the waste is taken from:	**Title :**	
	Signature :	

Figure 2.11 Waste transfer form (Official Gazette, 26 December 2004 No:25682)

REPUBLIC OF TURKEY

MINISTRY OF ENVIRONMENT &URBANIZATION

NATIONAL WASTE TRANSPORTATION FORM

A/B/C/D	**Form Serial Number:**	
	Form No:	

I)WASTE GENERATOR

1) Title of Firm:	13) Waste Code [1]
	14) Description of Waste [2]
2) Owner (s) of Firm	
	15) Consistency at 20ºC[4]
Address of Firm	
3) Name and Code of Province	
	16) Color[5]
4) District	
5) Area	17) Weight of Waste
6) Street	ton / kg
7) Door Number	18) Type of Packages and Containers[6]
8) Tax Identification Number	
9) Tax Deparment	19) Number of Packages and Containers
10) Telephone Number	19) Dispatch Date of Waste
11) Fax Number	20) Name of Individual Responsbile
	22) Identity Number of Individual Responsbile
12) H Number[3]	21) Signature of Individual Responsbile

II)CARRIER

1) Title of Firm	12) Vehicle License Number
2) Owner (s) of Firm	13) Vehicle Plate Number
Address of Firm	14) Mode(s) of Transport[7]
3) Name and Code of Province	
	15) Date of Delivery
4) District	
5) Area	16) Name of Individual Responsbile
6) Street	
	17) Identity Number of Individual Responsbile
7) Door Number	18) Signature of Individual Responsbile
8) Tax Identification Number	
9)Tax Deparment	
10) Telephone Number	
11) Fax Number	

III)WASTE PROCESSING FACILITY

1) Title of Firm	12) License Number of Firm
	13) Weight of Waste
2) Owner (s) of Firm	tons / kg
	14) Waste Disposal or Recovery Method[8]
Address of Firm	15) Transfer of Waste from an interim storage facility (enter X into related box)
	a) Waste not treated passed on to disposal/recovery facility
	b) Waste treated then passed on to disposal/recovery facility(no other type of waste generated)
3) Name and Code of Province	c) Waste treated then passed on to disposal/recovery facility(other type of waste generated)
4) District	d) Others (specify)
5) Area	16) Waste Acceptance Date
6) Street	
7) Door Number	17) Name of Individual Responsbile
8) Tax Identification Number	
	18) Identity Number of Individual Responsbile
9) Tax Department	
	19) Signature of Individual Responsbile
10) Telephone Number	
11) Fax Number	

Figure 2.12 National waste transportation form (Official Gazette, 20 March 2015, No:29301)

National Waste Transportation Form Explanation Guide

Licensed vehicles for Waste Transportation should keep Waste Transportation Forms. WASTE GENERATOR takes Form from Provincial Environmental Department. This form has 4 copies namely Form (A) with blue color, Form (B) with pink color, Form (C) with white color, Form (D) with green color. WASTE GENERATOR and CARRIER fill in these forms and submit to Provincial Environmental Department. Form (A) and (C) will be two copies.

a) The copy (D) of Form (9B) should be kept by WASTE GENERATOR just before starting international waste transportation, and has to be submit to Provincial Environmental Department by WASTE GENERATOR.
b) Copies (A), (B) and (C) of Form are given to CARRIER to keep during transportation.

c) Copies (A), (B) and (C) of Form are to be signed by WASTE PROCESSING FACILITY. WASTE PROCESSING FACILITY keeps (A) and (B) of Form. Copy (C) is taken by CARRIER and CARRIER should submit one copy of that to WASTE GENERATOR.

d) Filled in copy (A) is kept by WASTE PROCESSING FACILITY. One copy of it should be submitted to Ministry by WASTE PROCESSING FACILITY.

e) Filled in copy (B) of Form is submitted to WASTE GENERATOR by WASTE PROCESSING FACILITY.

All filled in forms should be kept for three years. Whenever authorized public organizations ask to control the procedure, they should be provided for them.

1) Waste Code: (Question 12 of section-consigner**)**, Will be filled in 6-digit form according to the Annex 7 of the Regulation on the Control of Hazardous Waste.

2) Descrıptıon of Waste : (Question 13 of section-consigner**)**, Will be filled according to the descriptions given in the Annex 7 of the Regulation on the Control of Hazardous Waste.

3) H Number (Question 11 of Section-Consigner)

It is also availabe in Annex 5 of Hazardous Waste Regulation

H1 Explosive

H2 Oxidizing

H3-A Highly Flammable

H3-B Flammable

H4 Irritant

H5 Harmful

H6 Toxic

H7 Carcinogenic

H8 Corrosive

H9 Infectious

H10 Teratogenic

H11 Mutagenic

H12 Substances and preparations which release toxic or very toxic gases in contact with water, air or an acid.

H13 Substances and preparations capable by any means, after disposal of yielding another substance, e.g:

H14 Ecotoxic

4)Consistency At 20º(Questıon 14 of Section-Consigner)

1 Powdery/Powder

2 Solid

3 Viscous/paste

4 Sludgy

5 Liquid

6 Gaseous

7 Other(specify)

5) Colors (Question 15 of Section-Consigner)

1 White

2 Brown

3 Red

4 Blue

5 Yellow

6 Black

7 Green

8 Other (specify)

6) Types of Packages and Containers (Question 17 of Section-Consigner)

1 Drum

2 Wooden barrel

3 Jerrican

4 Box

5 Bag

6 Composite packaging

7 Pressure receptacle

8 Bulk

9 Other (specify)

7) Mode(S) of Transport (Question 13 of Section-Carrier)

R Road

S Sea

T Train/Rail

A Air

W Inland Waterways

8) Disposal / Recovery Operations (Question 10 of Section-Consignee)

D1 Deposit into or onto land, (e.g. landfill, etc.)

D2 Land treatment, (e.g. biodegradation of liquid or sludgy discards in soils, etc.)

D3 Deep injection, (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)

D4 Surface impoundment, (e.g.placement of liquid or sludgy discards intopits, ponds or lagoons, etc.)

D5 Specially engineered landfill, (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment etc.)

D6 Release into a water body except seas/oceans

D7 Release into seas/oceans including sea-bed insertion

D8 Biological treatment not specified elsewhere in this list which results in final compounds or mixtures which are discarded by means of any of the operations numbered D1 to D12

D9 Physico-chemical treatment not specified elsewhere in this list which results in final compounds or mixtures which are discarded by means of any of the operations numbered D1 to D12 (e.g. evaporation, drying, calcination, neutralization. Precipitation, etc.)

D10 Incineration on land

D11 Incineration at sea

D12 Permanent storage, (e.g. emplacement of containers in mine, etc.)

D13 Blending or mixing prior to submission to any of the operations numbered D1 to D12

D14 Repackaging prior to submission to any of the operations numbered D1 to D13

D15 Storage pending any of the operations numbered D1 to D14 (excluding temporary storage pending collection, on site where it is produced)

R1 Use as fuel (other thain in direct incineration) or other means to generate energy

R2 Solvent reclamation/regeneration

R3 Recyling/reclamation of organic substances which are not used as solvents

R4 Recycling/reclamation of metals and metal compounds

R5 Recycling/reclamation of other inorganic materials

R6 Regeneration of acids or bases

R7 Recovery of components used for pollution abatement

R8 Recovery of compenents from catalysts

R9 Used oil re-refining or other reuses of oil

R10 Land treatment resulting in benefit to agriculture or ecological improvement

R11 Uses of wastes obtained from any of the operations numbered R1 to R10

R12 Exchange of wastes for submission to any operations numbered R1 to R11

R13 Storage of wastes pending any of the operations numbered R1 to R12 (excluding temporary storage, pending collection, on site where it is produced)

2.3.8 Waste Commission

Wastes accumulated in waste reception facility and generated by port activities have to be disposed by licenced disposal facility.

According to Regulation of Reception of Wastes from Ships and Waste Control that is published on 18 March 2010 dated and 27525 numbered, in port operations, before give wastes to licenced disposal facility, a commission which have 7-member gather. 2 of members are authorized person from Provincial Environmental Deparment, 1 of tmembers is financial office expert, 1 of them is section manager of revenue office, 1 of them is director of anti-smuggling and organized crime branch, 1 of them is individual responsible of environmental management section and last member is environmental engineer from consulting firm (Official Gazette, 2 April 2015 No: 29314).

There is an example about how commission report organizes in Figure 2.13:

WASTE RECEPTION FACILITY
COMMISSION MEETING REPORT

Because of the X Port Management's appeal, organized a meeting on ……. date and at …….. o'clock in meeting room.

Individual responsible of Waste Reception Facility declared that Waste Reception Facility has **…… m^3 bilge water, …….. m^3 sludge and ……... m^3 waste oil**.

Disposal of **…….. m^3 sludge waste, ……. m^3 bilge water(dewatered) waste and ……. m^3 waste oil** is demanded to send to licensed disposal or recycle facility and commission decided that sending waste to licensed disposal or recycle facility with National Waste Transportation Form.

After analyzed licenses and contracts; **decided to sending wastes which are…… m^3 bilge water(dewatered) waste (Waste Code: 13 05 06) and …… m^3 waste oil (Waste Code: 13 01 11) to X DİSPOSAL FACILITY, …….. m^3 sludge waste (Waste code: 13 07 03) to Y DISPOSAL FACILITY.**

Figure 2.13 Comission meeting report

2.4 Waste Reception Facility

According to Regulation of Reception of Wastes from Ships and Waste Control that is published on 18 March 2010 dated and 27525 numbered, port managements have to set up waste reception facility which have enough capacity and technical equipment to serve taking wastes generated by ships. And also port management have to get Environmental Permit and Licence.

Environmental consulting firm have to prepare project report and waste management plan for waste reception facility. This documents have to include these informations as follows (Official Gazette, 18 March 2005 No: 27525).

General Informations

- Name, address, telephone number, fax number of port management
- Information about people who prepare this report

Informations About Port and Waste Reception Facility

- Location of port and waste reception facility
- Purpose of service
- Informations about ships that is took advantage of service
- Number of ships
- Number of wastes generated by ships
- Capacity and qualification of waste reception facility
- Sketch of port and waste reception facility
- Utilization situation about infrastructure services and municipal services

Information About Implementation of Waste Management Plan

- Scope and purpose of Waste Management Plan
- Information about metods of taking wastes from ships
- Explanation how wastes are disposed
- Flow diagram for each kind of waste
- Documents for governorship, other concerned and port users
- Informatıon about incumbents of implementation of waste management plan

The most important step about preparing project report and waste management plan is calculation of tank capacity. Other informations was given other chapters.

2.4.1 Calculation of Tank Capacity

To calculate tank capacity, information about type and characteristic of ships is needed. According to professional experiences made Table 2.3

Table 2.3 Type and characteristic of ships

Type of Ship	**Max. Tonnage (DWT)**	**Type of Handled Loads**	**Equipments, incinerator-separator**
Container Ships	54.000	Container	available
Passenger-Cruise Ships	115.000	Passenger	available
Cargo Ships	18.000	Wet/dry fruits, glass, machine parts, palletized objects	available
Solid Bulk Carriers	17.500	Grain, Cossette, Clay, Clinker, Cemet	available
Liquid Bulk Carriers	17.000	Vegetable oil	available
Ro-Ro	54.000	Auto- construction equipment	available
Military Ships	24.000	-	available

2.4.1.1 Calculation for Capacity of Bilge Water Tank

Table 2.4 Calculation method for capacity of bilge water tank (Wiewióra & Listewnik, 2007).

Main Machine Category (kW)	Capacity (m^3)
<1.000	1.5
1.000 - 20,000	1.5 + (P-1.000)/1.500
>20.000	14.2 + 0.2 (P-20.000)/1.500

P: Main Engine Power

Table 2.5 Calculation for capacity of bilge water tank of ships

Type of Ship	**Average Ship Number per day**	**Tonnage (DWT)**	**Machine Power (kW)**	**Calculation for Bilge Water Tank Capacity (m^3)**	**Total Volume Calculation According to %80 occupancy and ship number**
Container Ships	3	54.000	6.000	1.5 + (6.000-1.000)/1.500 = 4.9 m^3	=4.9 m^3 x 3 x %80 = **11.76 m^3**
Passenger-Cruise Ships	1	115.000	11.000	1.5 + (11.000-1.000)/1.500 =8.2 m^3	= 8.2 m^3 x 1 x %80 = **6.56 m^3**
Cargo Ships	1	18.000	3.000	1.5 + (3.000-1.000)/1.500 =2.9 m^3	= 2.9 m^3 x 1 x %80 = **2.2 m^3**
Solid Bulk Carriers	1	17.500	3.000	1.5 + (3.000-1.000)/1.500 =2.9 m^3	= 2.9 m^3 x 1 x %80 = **2.32 m^3**
Liquid Bulk Carriers	1	10.000	2.000	1.5 + (2.000-1.000)/1.500 =2.2 m^3	= 2.2 m^3 x 1 x %80 = **1.76 m^3**
Ro-Ro	1	54.000	6.000	1.5 + (6.000-1.000)/1.500 =4.9 m^3	= 4.9 m^3 x 1 x %80 = **3.92 m^3**
TOTAL				**26.0 m^3**	**28.64 m^3**

2.4.1.2 Calculation for Capacity of Sludge Tank

The mininmum sludge tank capacity have to be calculated by following formula: (Wiewióra & Listewnik, 2007)

$$V = K \times C \times D \quad (2.1)$$

In this formula;

V: Sludge Tank Volume (m^3)

K: Coefficient (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 (tonnes)

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

Table 2.6 Calculation for capacity of sludge tank of ships

Type of Ship	Average Ship Number Per Day	Tonnage (DWT)	Machine Power (Kw)	Daily Fuel Oil Consumption (M^3)	Calculation for Sludge Tank Capacity (M^3/Ship)	Total Volume Calculation According to %80 Occupancy and Ship Number
Container Ships	3	54.000	6.000	21	=0.01 x 21 x 30 = 6.3 m^3	=6.3 m^3 x 3 x %80 =15.12 m^3
Passenger-Cruise Ships	1	115.000	11.000	45	=0.01 x 45 x 30 = 13.5 m^3	= 13.5 m^3 x 1 x %80 =10.80 m^3
Cargo Ships	1	18.000	3.000	7	=0.01 x 7 x 30 = 2.1 m^3	= 2.1 m^3 x 1 x %80 = 1.68 m^3
Solid Bulk Carriers	1	17.500	3.000	7	=0.01 x 4 x 30 = 1.2 m^3	= 2.1 m^3 x 1 x %80 =1.68 m^3
Liquid Bulk Carriers	1	10.000	2.000	4	=0.01 x 4 x 30 = 1.2 m^3	= 1.2 m^3 x 1 x %80 = 0.96 m^3
Ro-Ro	1	54.000	6.000	21	=0.01 x 21 x 30 = 6.3 m^3	= 6.3m^3 x 1 x %80 = 5.04 m^3
TOTAL					**31.5 m^3**	**35.28 m^3**

2.4.1.3 Calculation for Capacity of Waste Oil Tank

Minimum waste oil tank capacity is calculated by following formula (Marpol Training Institute (MTI), 2013)

Table 2.7 Calculation method for capacity of waste oil tank

Main Machine Category (kW)	**Capacity (m^3)**
<10.000	$20 \times D \times P/10^6$
>10.000	$D \times (0.2 + 7 \times (P-10.000)/10^6)$

D: Days
P: Main Engine Power

Table 2.8 Calculation for capacity of waste tank of ships

Type Of Ship	Average Ship Number Per Day	Tonnage (DWT)	Machine Power (Kw)	Daily Fuel Oil Consumption (m^3)	Calculation for Waste Oil Tank Capacity (M^3/Ship)	Total Volume Calculation According to %80 Occupancy and Ship Number
Container Ships	3	54.000	6.000	21	=20 x 30 x 6.000/10^6 =3.6 m^3	=3.6 m^3 x 3 x %80 =8.64 m^3
Passenger-Cruise Ships	1	115.000	11.000	45	= 30 x (0.2 + 7 x (11.000-10.000)/10^6) =6.3 m^3	=6.3 m^3 x 1 x %80 =5.04 m^3
Cargo Ships	1	18.000	3.000	7	=20 x 30 x 3.000/10^6 =1.8 m^3	=1.8 m^3 x 1 x %80 =1.44 m^3
Solid Bulk Carriers	1	17.500	3.000	7	=20 x 30 x 3.000/10^6 =1.8 m^3	=1.8 m^3 x 1 x %80 =1.44 m^3
Liquid Bulk Carriers	1	10.000	2.000	4	=20 x 30 x 2.000/10^6 =1.2 m^3	=1.2 m^3 x 1 x %80 =0.96 m^3
Ro-Ro	1	54.000	6.000	21	=20 x 30 x 6.000/10^6 =3.6 m^3	=3.6 m^3 x 1 x %80 =2.88 m^3
TOTAL					**18.3 m^3**	**20.04 m^3**

2.4.1.4 Calculation for Amount of Waste Water

Generally assuming that a person on ship generate 0.05 m^3 wastewater per day.

Table 2.9 Calculation for amount of waste water

Type of Ship	**Average Staff Number**	**Route + Actual Port Time (day)**	**Calculation for Amount of Waste Water (m^3/ship)**
Container Ships	10	1	=10 x 0.05 x 1day x 3ship = 1.50 m^3
Passenger-Cruise Ships	1.600	1	=1.600 x 0.05 x 1day x 1ship = 80 m^3
Cargo Ships	10	1	=10 x 0.05 x 2day x 1ship =1.00 m^3
Solid Bulk Carriers	10	1	=10 x 0.05 x 2day x 1ship =1.00 m^3
Liquid Bulk Carriers	10	1	=10 x 0.05 x 2day x 1ship =1.00 m^3
Ro-Ro	10	1	=10 x 0.05 x 2day x 1ship =1.00 m^3
TOTAL	**1.650**		**85.50 m^3**

Table 2.10 Liquid waste tank capacity of ships

Type of Ship	Tonnage (DWT)	Machine Power (kW)	Daily Fuel Consumption (m^3)	Bilge Water Tank Capacity/ship (m^3)	Sludge Tank Capacity/ship (m^3)	Waste Oil Tank Capacity/ship (m^3)
Container Ships	54.000	6.000	21	4.9	6.3	3.6
Passenger-Cruise Ships	115.000	11.000	45	8.2	13.5	6.3
Cargo Ships	18.000	3.000	7	2.9	2.1	1.8
Solid Bulk Carriers	17.500	3.000	7	2.9	2.1	1.8
Liquid Bulk Carriers	10.000	2.000	4	2,2	1,2	1.2
Ro-Ro	54.000	6.000	21	4.9	6.3	3.6

Port management have to design and set up waste reception facility according to results. They have to design tank capacities in accordance with calculated volumes of tanks.

2.5 Environmental Consultancy Process

Ports and harbours have to sign a contract with environmental consulting firm because of that its in Article 10.6, Appendix II of Environmental Permit and Licence Regulation which was entered into force on 10.09.2014.

According to Regulation about Environmental Attendants, Environmental Management Units and Environmental Consulting Firms which is entered into force on 23 November 2013, environmental consulting firms have some responsibilities as follows:

- From beginning of consulting service, montly auditing report has to be submitted until the 15. day of next month
- To prepare internal inspectation report in 30 days from the beginning of consulting service and every year.
- To get permission and licence for operation according to Environmental Permit and Licence Regulation which was entered into force on 10.09.2014.
- To visit the operation that is in Appendix I of to Environmental Permit and Licence Regulation at least 2 days, operation that is in Appendix II at least 1 day of month

2.5.1 Temporary Activity Certificate and Environmental Permit Process

Operations which are in Appendix I or Appendix II of Environmental Permit and Licence Regulation have to be get environmental permit or licence. This process includes 2 step which are application for Temporary Activity Certificate and application for Environmeental Permit and Licence.

Operations have to make e-application to get temporary activity certificate and environmental permit. This e-application have to be made by by environmental management unit, environmental official employed, or environmental consulting firms which is authorized by the Ministry of Environment and Urbanization.

To make e-application for temporary activity certificate and environmental permit, reqired documents which are two parts as common and private documents that are shown follows have to be submitted (Official Gazette, 10 September 2014 No:29115).

Common Documents for Temporary Activity Certificate:

- Application form
- Document of environmental impact assessment
- Trade registry gazette
- Capacity report
- Flow process chart and process summary

Private Documents for Temporary Activity Certificate:

Private Documents for Temporary Activity Certificate show differences according to type of certificate which are permit or licence

According to permit subject:

Below-stated private document is reqired for all subject of permit except environmental permit about ambient noise.

- Provincial Directorate Letter of Confirmity

According to licence subject:

Required documents according to licence subject are shown by following table:

Table 2.11 Reqired documents according to licence subjects (Official Gazette, 10 September 2014 No:29115).

LICENCE SUBJECTS	Recovery	Hazardous Waste Non-Hazardous Waste Waste Oil Vegetable Waste Oil Waste Battery and Accumulator Tyre That Has Completed Its Life-Cycle Package Waste	-Provincial Directorate Letter of Conformity - Industry Registration Certificate -Liability insurance
	Disposal	Incineration of Waste and Co-Incineration	-Provincial Directorate Letter of Conformity -Liability insurance
		Advanced Thermal Processing	-Provincial Directorate Letter of Conformity -Liability insurance
		Landfill	-Provincial Directorate Letter of Conformity - Landfill Facility Approval Certificate - Liability insurance -Working drawing
	Interim	Waste Interim Storage Facility	-Provincial Directorate Letter of Conformity -Liability insurance
	Processing	Medical Waste Sterilization	Provincial Directorate Letter of Conformity -Compliance documents of sterilization equipment -Liability insurance
		Collecting and Sorting Package Waste	-Provincial Directorate Letter of Conformity
		Ship Recovery Facility	-Provincial Directorate Letter of Conformity -Liability insurance
		Refuse-Derived Fuel	-Provincial Directorate Letter of Conformity -Liability insurance
		Tanker Cleaning	-Provincial Directorate Letter of Conformity -Liability insurance
		Scrap Metal/Waste Processing	-Provincial Directorate Letter of Conformity
		Scrap Waste Interim Storage	-Provincial Directorate Letter of Conformity
		Waste Electrical and Electronic Equipment	-Provincial Directorate Letter of Conformity -Liability insurance
		Waste Reception Facility	-Waste Reception Facility Approval Document
	Decontamination	Pcb Decontamination	-Provincial Directorate Letter of Conformity -Liability insurance

Application form and reqired informations are as follows:

Table 2.12 Temporary activity certificate application form (Official Gazette, 10 September 2014 No:29115).

TEMPORARY ACTVITY CERTIFICATE APPLICATION FORM

1.	Name of the Facility/ Activity	:	
2.	Address of the Facility/ Activity	:	Tel: Fax: Web: e-mail:
3.	City	:	
4.	County	:	
5.	Island, Parcel and Map Number	:	Island: Parcel: Map (Cadastral Map):
6.	Coordinate Information	:	Right Value (Y): .... (m) Top Value (X): .... (m) Zone Number: Map (map of 1/25.000'): Not: Coordinates shall be written in compliance with 1/25.000 scale topographic maps, in ED-50 datum, according to UTM zones.
7.	Tax Office and Number	:	
8.	SSI Workplace Registration No	:	
9.	Trade / Industry. Chamber No	:	
10.	T.R. Identity Number of Facility Owner / Authority T.R. Identity Number of Directorate General of Facility	: :	
11.	Economic Activity Area of Institution / Agency or Business (NACE code)	:	..... (Please select)
12.[1]	Production subject	:	
13.[1]	Annual Production Capacity	:	Product type Capacity ....
14.[1]	Facility/Activity's	:	A. Total Area (m^2): B. Closed Area (m^2): C. Number of Shifts: Ç. Number of employees: D. Daily Average Working Time (Hours): Total Working Time (Working day/year): E. Working Type: □ Continuous □ Discrete If discrete, daily average working time: .....
15.	Location Where Facility/Activity is Installed	:	□ Industrial Area □ Settlement Area □ Noise Sensitive Area (Hospitals, Schools, etc.) □ Within the Borders of Contiguous Area □ Outside the Borders of Contiguous Area □ Protected Area (Area whose Protected Status is Designated by Legislation) □ Organized Industrial Zone □ Specialization Industrial Area □ Others (please specify) .....
16.	Permits Received in the Scope of By-law on Environmental Impact Assessment	:	□ EIA Positive Decision □ EIA Not Required Decision □ Outside the Scope of EIA

[1]: They shall be received from the information in the capacity report.

After getting temporary activity certificate, application have to be made for environmental permit or environmental permit and licence. Required documents for this step are shown by following table:

Table 2.13 Required documents for environmental permit (Official Gazette, 10 September 2014 No:29115).

Environmental Permit/Licence Subject			Required Documents to Complete the Application Process
PERMIT SUBJECTS	Air Emission		- Emission Measurement Report
	Ambient Noise		- Acoustic Report
	Wastewater Discharge		- Waste Disposal Technical Information List -Project approval or document which is proved that wastewater treatment system builded before the date of 12/10/2004
	Deep Sea Discharge		Waste Disposal Technical Information List -Project approval
LICENCE SUBJECTS	Recovery	Hazardous Waste Non-Hazardous Waste Waste Oil Vegetable Waste Oil Waste Battery and Accumulator Tyre That Has Completed Its Life-Cycle Package Waste	-Technical Compatibility Report - Energy Market Regulatory Authority Oil License (only for the waste oil)
	Disposal	Incineration of Waste and Co-Incineration	-Trial Incineration Plan -Post- Trial Incineration Report
		Advanced Thermal Processing	- Technical Compatibility Report -Trial Incineration Plan -Post- Trial Incineration Report
		Landfill	-Monitoring Reports
	Interim Storage	Waste Interim Storage Facility	- Technical Compatibility Report
	Processing	Medical Waste Sterilization	- Technical Compatibility Report
		Collecting and Sorting Package Waste	- Technical Compatibility Report
		Ship Recovery Facility	- Technical Compatibility Report
		Refuse-Derived Fuel	- Technical Compatibility Report
		Tanker Cleaning	- Technical Compatibility Report
		Scrap Metal/Waste Processing	- Technical Compatibility Report
		Scrap Waste Interim Storage	- Technical Compatibility Report
		Waste Electrical and Electronic Equipment	- Technical Compatibility Report
		Waste Reception Facility	- Activity Report
	Decontamination	Pcb Decontamination	- Technical Compatibility Report

Temporary Activity Certificate and Environmental Permit process steps are shown by following Figure:

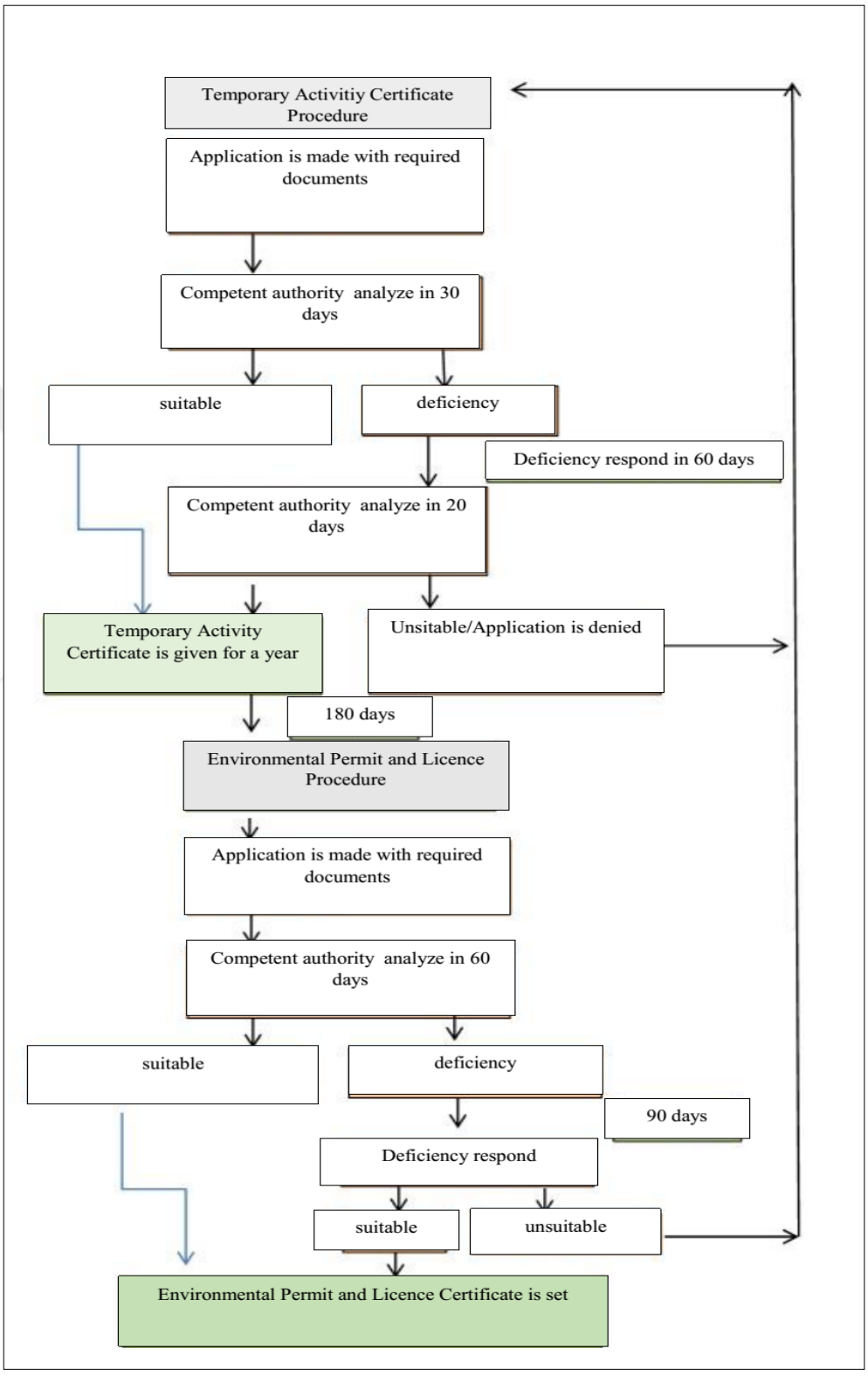

Figure 2.14 Environmental permit and licence procedure

2.5.2 Internal Inspectation Report

Internal inspactation report include details about operation according to environmental law and regulations that operation is obliged to. There is an example internal inspectation report that is prepared for port management. There is an internal inspectation form that was made for X Port Management in appendix.

CHAPTER THREE
EVALUATION OF CARBON FOOTPRINT IN HARBOURS

Global warming is one of the main problems about environment. Greenhouse gases (GHGs) warm the Earth by absorbing energy and causes global warming (EPA, 2016).

Greenhouse gas (GHGs) is the most common term, mentioning to to any gas in the atmosphere that causes to a greenhouse effect, trapping thermal radiation from the sun in the Earth's atmosphere. There are a few kinds of GHGs in Earth's atmosphere which are water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and others. Each gas has different greenhouse effects; for example, methane has a much greater greenhouse effect than CO_2 (Brewer, 2009).

However, CO_2 is existed in a lot more quantities in the atmosphere than methane. Water vapor is the largest component of the greenhouse effect, but its contribution is not growing rapidly as CO_2 is, and humans don't have as much control over water vapor as they do over CO_2 emissions. Because of these reasons, most climate change mitigation focuses on CO_2 emissions (Brewer, 2009).

Carbon footprint is very popular term recent years. According to Wiedman and Minx, there is no standartdized definition of carbon footprint. They offer the following definition (Brewer, 2009):

"The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product"

Carbon footprint is defined in other way that when you drive a car, the engine burns fuel that creates a certain quantity of CO_2, depending on engines fuel consumption and the distance. When you heat your house with oil, gas or coal, then you also generate CO_2 release. Even if you heat your house with electricity, the generation of the electrical power may also have created a certain amount of CO_2. When you buy food

and goods, the production of these also release some quantities of CO_2 (Wikipedia, 2016).

3.1 Emissions Sources of Ports and Harbours

There are many emission sources of ports and harbours which have two types named directly and indirectly. These type of emissions generated by followings:

- ships,
- power plants that provides power for offices,
- electrified cargo handling equipment,
- fuel-powered cargo handled equipment,
- trucks,
- rail locomotives etc.

These sources create greenhouse gases, especially carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), and other pollutants of concern, such as oxides of nitrogen (NO_x), particulate matter (PM), and sulfur oxides (SO_x)

Port activities that produce emissions can be grouped as the following scopes: (Carbon Footprint Working Group (CFWG), 2010).

- **Scope 1- Port Direct Sources:** Sources which are directly controlled by operation such as port-owned vehicles, buildings, port-owned equipments and other port-owned sources.
- **Scope 2- Port Indirect Sources:** Sources which are purchased electricity, steam, heating or cooling for operation.
- **Scope 3- Other Indirect Sources:** These sources which are releated with tenant operations and ships, trucks, cargo handling equipment, rail locomotives, tenant buildings, tenant purchased electricity, and port and tenant employee commuting (train, personal car, public transportation, etc.) (CFWG, 2010).

These scopes are shown by following Figure:

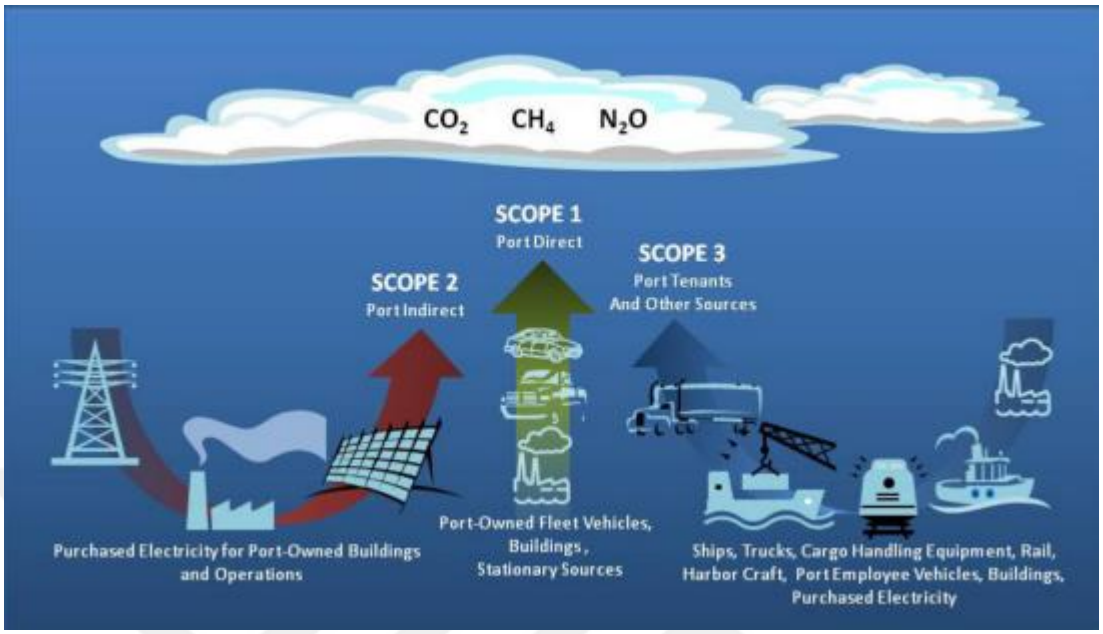

Figure 3.1 Emission sources of ports and harbours (CFWG, 2010).

Figure 3.1 shows some similarities between Scope sources. For example, Scope 3 sources such as equipments, buldings etc. can be own by port and then they will be Scope 1 sources. Emissions generated by purchased electricity can be Scope 2 or Scope 3 sources depending on that ownership situation about electricity consuming operation.

3.2 Emission Inventory

There are three data types which are very important to developing carbon footprint or other air pollutants such as NO_x, SO_x, PM etc. inventory. These data types are as follow:

- **Source data:** This type of data details source characteristics which are engines rating or size or power plant, fuel consumption type, information about engine technology, age of the engine, manufacturer, model, etc. (CFWG, 2010).

- **Activity Data:** This type of data include information about how equipment operates and how the energy use change by operation mode (CFWG, 2010).

- **Emissions Test Data or Emission Factors:** The model that includes emission factors converts the mass or volume of material or energy into CO_2-eq emission rates by using ready-made patterns. Emission factors are the most commonly used model in a carbon footprint (Sarbring, 2014).

3.2.1 Approaches to Detemination of Emission Inventory

There are three kind of approach generally used in developing carbon footprint inventories which are as following (CFWG, 2010).

- Activity-Based
- Surrogate-Based
- Hybrid

Activity-Based Approach

- This approach most commonly used for actual port operations
- Specific datas is used such as actual consumptions of power and fuel, actual engine raitings
- Uses informations like operation operation hours, vessel call data etc. which are specific activity data of equipments
- Can provide to converting power or fuel consumption into emission estimates

Surrogate-Based Approach

- Uses lower accuracy data than activity-based data
- Uses surrogate datas that was published as study, documents etc.

Hybrid Approach

- Uses combination of surrogate-based and active-based datas
- Uses data according to their availability or limited time

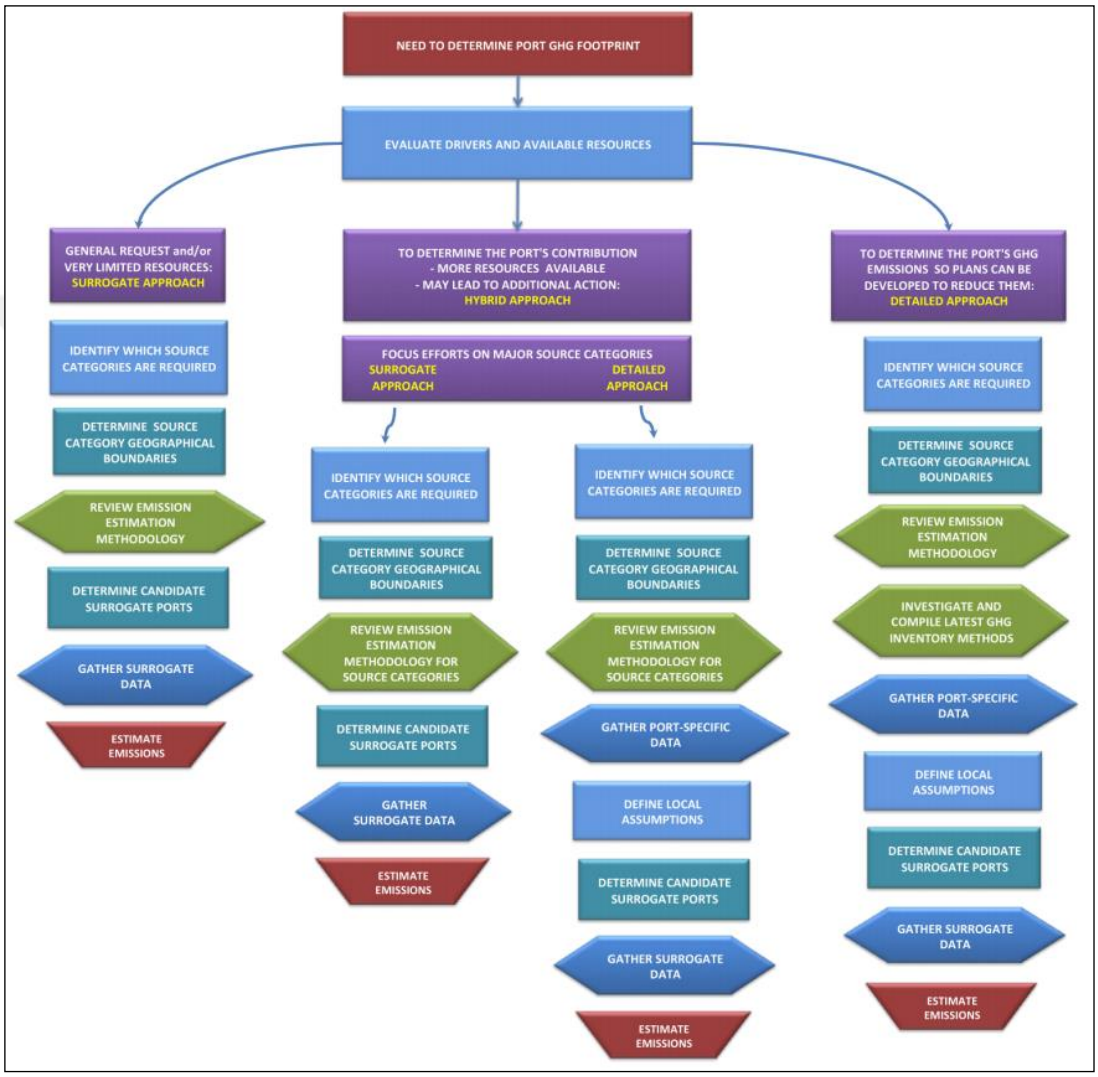

Figure 3.2 Approaches of Emission Inventory (CFWG, 2010)

3.2.2 Boundaries of Inventory

Determinating boundaries is a very important step to organize emission inventory. Also priorities have to be determined because of that to make reasonable assumption. The process therefore depends on the objective for the footprint and characteristics for the product or activity (Sarbring, 2014).

3.3 Calculation of Carbon Footprint

To calculate carbon footprint, an estimation method has to be used. Method is used according to information that is had. After data collection, most suitable method is determined.

There are some critical terms and definitions that is used to calculate carbon footprint. Most important of them global warming potential and emission factor.

3.3.1 Global Warming Potential

Greenhouse gases (GHGs) are not equal. Each greenhouse gas has a unique atmospheric lifetime and heat-trapping potential.

Global Warming Potential (GWP) terms has been developed to allow the comparison of the ability of each greenhouse gas to trap heat in the atmosphere relative to CO_2 (carbon dioxide) over a specified time horizon. Often, greenhouse gas emissions are calculated in terms of how much CO_2 would be required to produce a similar warming effect oven the chosen time horizon. This is named the carbon dioxide equivalent (CO_2E) value and is calculated by multiplying the amount of gas by its associated global warming potential (GWP) (Environment and Climate Change Canada, 2015).

The following table shows 100-year time horizon global warming potentials (GWP) relative to CO_2. This table is adapted from table 2.14 of the IPCC Fourth Assessment Report, 2007. The 4^{th} assessment report values are the most recent (2007), but the second assessment report values (1995) are also listed (Greenhouse Gas Protocol (GGP), 2016).

Table 3.1 Global warming potential some greenhouse gases (GGP, 2016).

Designation or common name	Chemical formula	Second assessment report (SAR)	4th assessment report (AR4)
Carbon dioxide	CO_2	1	1
Methane	CH_4	21	25
Nitrous oxide	N_2O	310	298
Substances			
CFC-11	CClaF	3.800	4.750
CFC-12	CCl_2F_2	8.100	10.900
CFC-13	CClFa		14.400
CFC-113	CCl_2FCClF_2	4.800	6.130
CFC-114	$CClF_2CClF_2$		10.000
CFC-115	CQF_2CF_3		7.370
Halon-1301	$CBrF_3$	5.400	7.140
Halon-1211	$CBrClF_2$	1	1.890
Halon-2402	$CBrF_2CBrF_2$		1.640
Carbon tetrachloride	CCl_4	1.400	1.400
Methyl bromide	CH_3Br		5
Methyl chloroform	CH_3CCl_3	100	146

3.3.2 Emission Factor

An emissions factor is a value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (EPA, 2016).

3.3.3 Calculation of Ships Carbon Footprint

The emission from ships is generated by three activities which are:

- **propulsion system:** it provides movement for the ship through water,
- **auxiliary power system:** it provides for the electrical demands during ship operations,
- **auxiliary boilers:** it produces hot water and steam for use in the engine room and for crew amenities.

All these activities use several kind of equipment which are operated differently according to the mode of ship operating.

3.3.3.1 Propulsion Systems

There are a few kind of propulsion system in ships. The most common of these are direct drive, geared drive, diesel/electric and steam powered gear/drive.

Direct-drive system has low speed engine and large high-kW rate. They are commonly used in bulk carriers, container ships nad RoRos. Gear-drive system has medium speed engine and medium high-kW rate. Diesel-electric system has also medium speed engine and medium high-kW rate. They can have one or more engine. Steam Powered/Gear-Drive system have boilers that has medium-kW rate. Type of propulsion systems are shown in Figure 3.3.

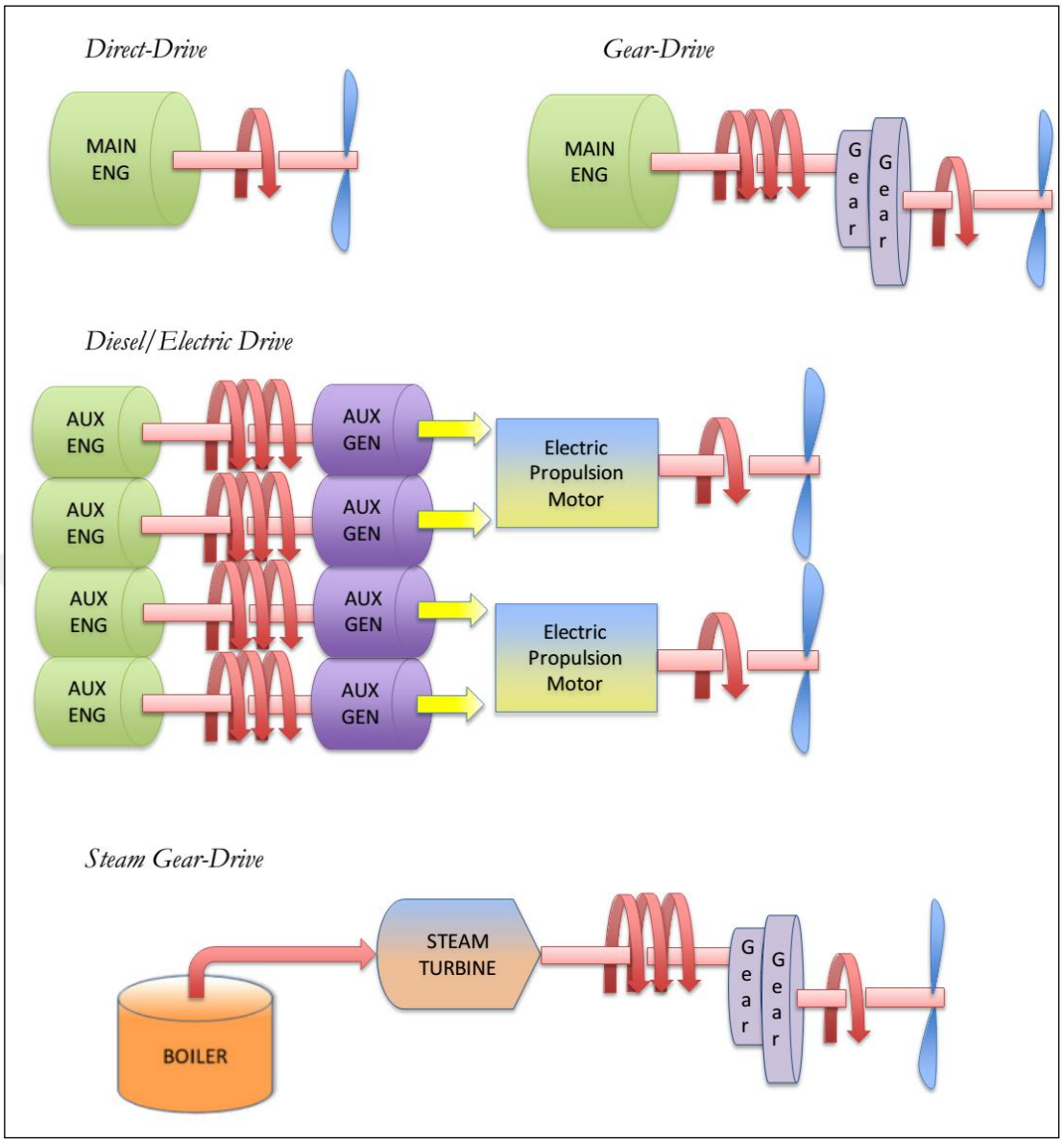

Figure 3.3 Type of propulsion systems (CFWG, 2010).

3.3.3.2 Auxiliary Power Systems

This system provides energy during the ground operations of ships. It provides electricity, shaft power etc. They usually design with extra capacity to provide energy when engine shut down or happen mechanical break down. This system is commonly used as diesel-electric type, especially for gear-drive and direct-drive disegned ships. Type of auxiliary systems are shown in Figure 3.4.

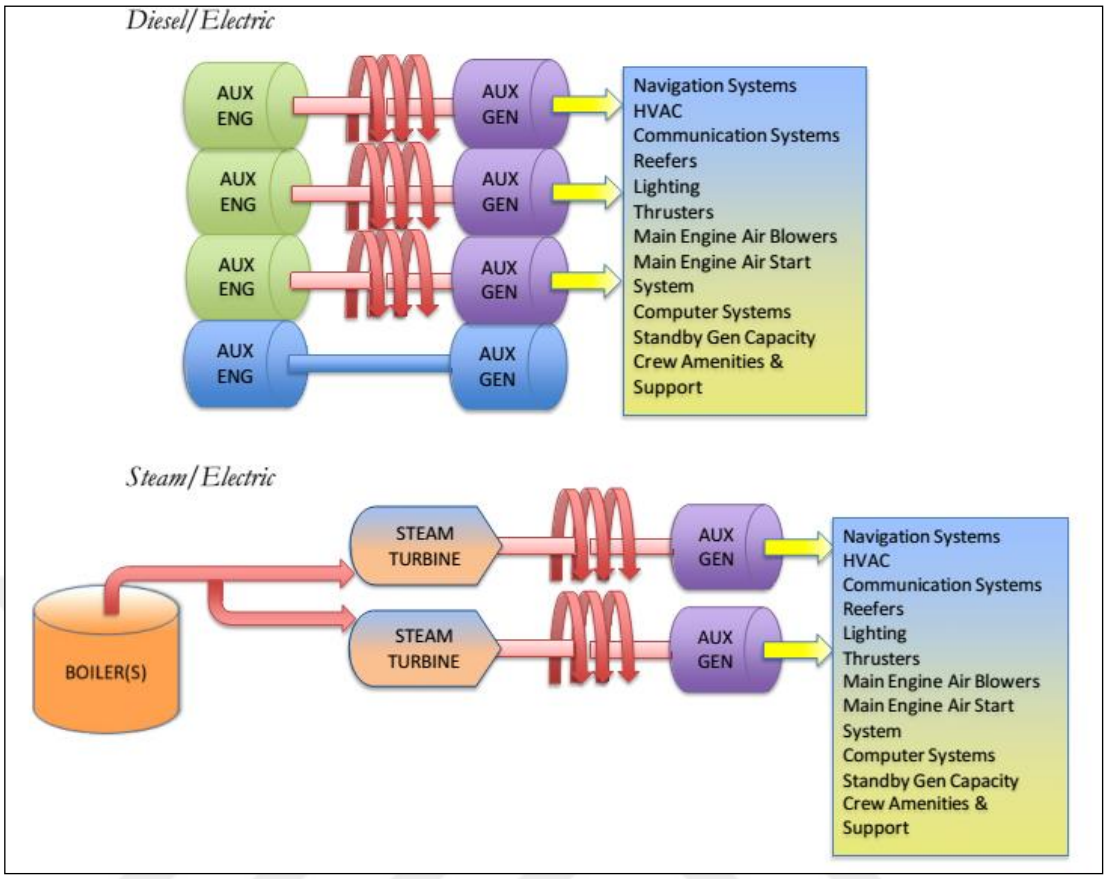

Figure 3.4 Type of auxiliary power systems (CFWG, 2010).

There are three operation mode for ships which are transit, maneuvering and hoteling (City of Richmond California (CRC), 2015).

Transit mode:

Transit mode means that ship is navigating in open ocean or unrestricted waters. When the ships are in transit mode:

- Its speed is sea-speeds
- It consumes fuel at highest level
- Propulsion engines operate at highest load

Maneuvering mode:

- Its speed is slowest
- It consumes fuel at lowest level
- Auxiliary boilers run
- Propulsion engines operate at low load

Hotelling mode:

- During this mode ship is not moving
- It consumes fuel at high or medium level depends on auxiliary engines and boilers situations
- Propulsion engines don’t run

Greenhouse gas emission can be calculated by following formula: (Herbert Engineering Corp. (HEC) 2011)

$$Emission = MCR \times LF \times T \times EF \quad (3.1)$$

MCR = Maximum Continious Rating of the combustion engine in use (kW)
LF = Load Factor
A = Activity time (hours)
EF = Emission factor (CO_2E/kW-h)

In this study, carbon footprint of ships was calculated because of the information that was had.

Table 2.2 shows that how many ships was came into X Port Management. Also, there are assumptions about what kind of ships coming, their tonnages and their visiting times in Section 2.3. These are boundaries for calculation.

In the light of this informations, calculation of carbon footprint of ships that was came into X Port Management.

From Table 2.2 and section 2.3, some approaches that is about percentage distribution was made. And following table shows main datas to calculate carbon footprint of ships that was came into X Port Management.

Table 3.2 Type, numbers and tonnages of ships that came into X Port Management

Ship	**Average Ship Number per year**	**Tonnage (DWT)**	**TEU**
Container Ships	573	54.000	4000
Passenger-Cruise Ships	192	115.000	-
Cargo Ships	192	18.000	2000
Solid Bulk Carriers	192	17.500	2000
Liquid Bulk Carriers	192	10.000	1000
Ro-Ro (coastal)	193	54.000	-

To calculate carbon footprint of ships several datas are needed which are shows following:

- Ships built year
- Propulsion system
- Auxiliary power system
- Transit mode distance
- Maneuvering mode distance
- Maneuvering mode speed
- Average MCR
- Average hoteling time
- Average max rated speed
- Average sea-speed
- Load factor
- Emission factor
- Average auxiliary load (transit mode)
- Average auxiliary load (maneuvering mode)
- Average auxiliary load (hotelling mode)
- Average boiler load (transit mode)
- Average boiler load (maneuvering mode)
- Average boiler load (hotelling mode)

3.3.3.3 Calculation for Container Ships Carbon Footprint

To calculate carbon footprint of container ships there are several assumptions and datas that are showing in Table 3.3:

Table 3.3 Assumptions and datas (CFWG, 2010; HEC, 2011; Ritchie, et al., 2002; Starcrest Consulting Group (SCG), 2008, 2016).

	Unit			
Built Year		2000+		
Propulsion System		Medium Speed-Diesel		
Auxiliary Power System		Medium Speed-Diesel/Electric		
Transit Mode Distance	Nm	35		
Maneuvering Mode Distance	Nm	7.5		
Maneuvering Mode Speed	Knot	9		
Hostelling Time	hour	5.3		
Average MCR	kW	39672		
Average Max Speed Rate	Knot	24		
Average Sea-Speed	Knot	22.5		
		Main Engine	Auxiliary Engine	Auxiliary Boiler
Average Auxiliary Loads For Auxilary Engine(Transit)	kW		1434	
Average Auxiliary Loads For Auxilary Engine(Maneuvering)	kW		2526	
Average Auxiliary Loads For Auxilary Engine(Hotelling)	kW		1298	
Average Boiler Loads(Transit)	kW			0
Average Boiler Loads(Maneuvering)	kW			501
Average Boiler Loads(Hotelling)	kW			501
Emission Factor	CO_2E/kW-hr	692.8	692.8	994.8
Load Factor (Transit)	-	0.8	0.13	
Load Factor (Maneuvering)	-	0.03	0.5	
Load Factor (Hoteling)	-	0	0.17	
Time(Transit Mode Distance/Sea-Spead)	hours	1.55		
Ship Number	per year	573	573	573
Legs/Visit	-	2	2	2

3.3.3.3.1 Calculation for Main Engines. Calculations are made by Following Equations:

Transit Mode:

$$E = MCR \times LF \times T \times EF$$

$E_{one\text{-}way}$ = 39672 kW x 0.8 x (35nm/22,6 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 34.5 tonnes CO_2E

$E_{transit}$ = 34.5 tonnes CO_2E/kW-hr x 2 visit/legs x 573

$E_{transit}$ = 39023.5 tonnes CO_2E

Maneuvering Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 39672 kW x 0.03 x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.69 tonnes CO_2E

$E_{transit}$ = 0.69 tonnes CO_2E/kW-hr x 2 visit/legs x 573

$E_{transit}$ = 787.4 tonnes CO_2E

$E_{total\text{-}main}$ = 787.4 tonnes CO_2E + 39023.5 tonnes CO_2E

$E_{total\text{-}main}$ = 39810.9 tonnes CO_2E

3.3.3.3.2 Calculation for Auxiliary Engines. Calculations are made by Following Equations: (CFWG, 2010).

Transit Mode:

$$E = AL \times T \times EF \quad (3.2)$$

AL = Auxiliary load

$E_{one\text{-}way}$ = 1434 kW x (35nm/22,6 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 1.54 tonnes CO_2E

$E_{transit}$ = 1.54 tonnes CO_2E/kW-hr x 2 visit/legs x 573

$E_{transit}$ = 1763.2 tonnes CO_2E

Maneuvering Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 2526 kW x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 1.46 tonnes CO_2E

$E_{maneuvering}$ = 1.46 tonnes CO_2E/kW-hr x 2 visit/legs x 573

$E_{maneuvering}$ = 1671.3 tonnes CO_2E

Hotelling Mode: Calculation are made by following equation: (CFWG, 2010).

$$E = AL \times T_h \times EF \quad (3.3)$$

Th = Hotelling time

$E_{hotelling}$ = 1298 kW x 5.3 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 4.76 tonnes CO_2E

$E_{total\text{-}aux}$ = 4.76 tonnes CO_2E+1671.3 tonnes CO_2E+1763.2 tonnes CO_2E

$E_{total\text{-}aux}$ = 3439.2 tonnes CO_2E

3.3.3.3.3 Calculation for Auxiliary Boilers. Calculations are made by Following Equations: (CFWG, 2010).

Maneuvering Mode:

$$E = BL \times T \times EF \quad (3.4)$$

BL =Boiler load

$E_{one\text{-}way}$ = 501 kW x (7.5nm/9 knot) hour x 994.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.42 tonnes CO_2E

$E_{maneuvering}$ = 0.42 tonnes CO_2E/kW-hr x 2 visit/legs x 573

$E_{maneuvering}$ = 475 tonnes CO_2E

Hotelling Mode: Calculations are made by Following Equations: (CFWG, 2010).

$$E = BL \times T_h \times EF \quad (3.5)$$

BL =Boiler load

Th = Hotelling time

$E_{hotelling}$ = 501 kW x 5.3 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 2.64 tonnes CO_2E

$E_{total\text{-}boil}$ = 2.64 tonnes CO_2E +475 tonnes CO_2E

$E_{total\text{-}boil}$ = 478.6 tonnes CO_2E

Total carbon footprint for Container Ships:

$E_{total\text{-}container} = E_{total\text{-}main} + E_{total\text{-}aux} + E_{total\text{-}boil}$

$E_{total\text{-}container}$ = 39810.9 tonnes CO_2E + 3439.2 tonnes CO_2E + 478.6 tonnes CO_2E

$E_{total\text{-}container}$ = 43728.8 tonnes CO_2E

3.3.3.4 Calculation for Passenger-Cruise Ships Carbon Footprint

To calculate carbon footprint of Passenger-Cruise Ships there are several assumptions and datas are shown in Table 3.4:

Table 3.4 Assumptions and datas (CFWG, 2010; HEC, 2011; Ritchie, et al., 2002; SCG, 2008, 2016).

	Unit			
Built Year		2000+		
Propulsion System		Medium Speed-Diesel		
Auxiliary Power System		Medium Speed-Diesel/Electric		
Transit Mode Distance	Nm	35		
Maneuvering Mode Distance	Nm	7,5		
Maneuvering Mode Speed	Knot	11		
Hostelling Time	hour	4		
Average MCR	kW	6889		
Average Max Speed Rate	Knot	22.3		
Average Sea-Speed	Knot	21		
		Main Engine	Auxiliary Engine	Auxiliary Boiler
Average Auxiliary Loads For Auxilary Engine(Transit)	kW		7058	
Average Auxiliary Loads For Auxilary Engine(Maneuvering)	kW		9718	
Average Auxiliary Loads For Auxilary Engine(Hotelling)	kW		7058	
Average Boiler Loads(Transit)	kW			0
Average Boiler Loads(Maneuvering)	kW			1000
Average Boiler Loads(Hotelling)	kW			1000
Emission Factor	CO_2E/kW-hr	692.8	692.8	994.8
Load Factor (Transit)	-	0.8	0.13	
Load Factor (Maneuvering)	-	0.03	0.5	
Load Factor (Hoteling)	-	0	0.17	
Time(Transit Mode Distance/Sea-Spead)	hours	0.68		
Ship Number	per year	192	192	192
Legs/Visit	-	2	2	2

3.3.3.4.1 Calculation for Main Engines. Calculations are made by Following Equations

Transit Mode:

using equation (3.1)

$E_{one\text{-}way}$ = 6889 kW x 0.8 x (35nm/21 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 6.36 tonnes CO_2E

$E_{transit}$ = 6.36 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 2443.5 tonnes CO_2E

Maneuvering Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 6889 kW x 0.03 x (7.5nm/11 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.097 tonnes CO_2E

$E_{transit}$ = 0.097 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 37.5 tonnes CO_2E

$E_{total\text{-}main}$ = 2443.5 tonnes CO_2E+ 37.5 tonnes CO_2E

$E_{total\text{-}main}$ = 2481.11 tonnes CO_2E

3.3.3.4.2 Calculation for Auxiliary Engine. Calculations are made Following Equations

Transit Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 7058 kW x (35nm/21 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 8.14 tonnes CO_2E

$E_{transit}$ = 8.14 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 3129.5 tonnes CO_2E

Maneuvering Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 9718 kW x (7.5nm/11 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 4.59 tonnes CO_2E

$E_{maneuvering}$ = 4.59 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 1762.7 tonnes CO_2E

Hotelling Mode:

Using equation (3.3)

$E_{hotelling}$ = 7058 kW x 4 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 19.6 tonnes CO_2E

$E_{total\text{-}aux}$ = 3129.5 tonnes CO_2E +1762.7 tonnes CO_2E +19.6 tonnes CO_2E

$E_{total\text{-}aux}$ = 3439.2 tonnes CO_2E

3.3.3.4.3 Calculation for Auxiliary Boilers. Calculations are made by Following Equations

Maneuvering Mode:

Using equation (3.4)

$E_{one\text{-}way}$ = 1000 kW x (7.5nm/11 knot) hour x 994.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.58 tonnes CO_2E

$E_{maneuvering}$ = 0.58 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 260.5 tonnes CO_2E

Hotelling Mode:

Using equation (3.5)

$E_{hotelling}$ = 1000 kW x 4 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 3.9 tonnes CO_2E

$E_{total\text{-}boil}$ = 260.5 tonnes CO_2E +3.9 tonnes CO_2E

$E_{total\text{-}boil}$ = 264.4 tonnes CO_2E

Total carbon footprint for Passenger Cruise Ships:

$E_{total\text{-}cruise}$ = $E_{total\text{-}main}$ + $E_{total\text{-}aux}$ + $E_{total\text{-}boil}$

$E_{total\text{-}cruise}$ = 2481.11 tonnes CO_2E + 4911.7 tonnes CO_2E + 264.4 tonnes CO_2E

$E_{total\text{-}cruise}$ = 7557.3 tonnes CO_2E

3.3.3.5 Calculation for Cargo Ships Carbon Footprint

To calculate carbon footprint of Cargo Ships there are several assumptions and datas that are shown in Table 3.5:

Table 3.5 Assumptions and datas (CFWG, 2010; HEC, 2011; Ritchie, et al., 2002; SCG, 2008, 2016).

	Unit			
Built Year		2000+		
Propulsion System		Medium Speed-Diesel		
Auxiliary Power System		Medium Speed-Diesel/Electric		
Transit Mode Distance	Nm	35		
Maneuvering Mode Distance	Nm	7,5		
Maneuvering Mode Speed	Knot	11		
Hostelling Time	hour	21.5		
Average MCR	kW	2917		
Average Max Speed Rate	Knot	13.7		
Average Sea-Speed	Knot	12.9		
		Main Engine	Auxiliary Engine	Auxiliary Boiler
Average Auxiliary Loads For Auxilary Engine(Transit)	kW		516	
Average Auxiliary Loads For Auxilary Engine(Maneuvering)	kW		1439	
Average Auxiliary Loads For Auxilary Engine(Hotelling)	kW		516	
Average Boiler Loads(Transit)	kW			0
Average Boiler Loads(Maneuvering)	kW			252
Average Boiler Loads(Hotelling)	kW			252
Emission Factor	CO_2E/kW-hr	692.8	692.8	994.8
Load Factor (Transit)	-	0.8	0.13	
Load Factor (Maneuvering)	-	0.03	0.5	
Load Factor (Hoteling)	-	0	0.17	
Time(Transit Mode Distance/Sea-Spead)	hours	0.68		
Ship Number	per year	192	192	192
Legs/Visit	-	2	2	2

3.3.3.5.1 Calculation for Main Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 2917 kW x 0.8 x (35nm/12.9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 4.39 tonnes CO_2E

$E_{transit}$ = 4.39 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 1684.4 tonnes CO_2E

Maneuvering Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 2917 kW x 0.03 x (7.5nm/11 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.04tonnes CO_2E

$E_{transit}$ = 0.04 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 15.9 tonnes CO_2E

$E_{total\text{-}main}$ = 1684.4 tonnes CO_2E + 15.9 tonnes CO_2E

$E_{total\text{-}main}$ = 1700.3 tonnes CO_2E

3.3.3.5.1 Calculation for Auxiliary Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 516 kW x (35nm/12.9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.97 tonnes CO_2E

$E_{transit}$ = 0.97 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 372.45 tonnes CO_2E

Maneuvering Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 1439 kW x (7.5nm/11 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.68 tonnes CO_2E

$E_{maneuvering}$ = 0.68 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 261.02 tonnes CO_2E

Hotelling Mode:

Using equation (3.3)

$E_{hotelling}$ = 516 kW x 21.5 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 7.69 tonnes CO_2E

$E_{total\text{-}aux}$ = 372.45 tonnes CO_2E +261.02 tonnes CO_2E +7.69 tonnes CO_2E

$E_{total\text{-}aux}$ = 641.15 tonnes CO_2E

3.3.3.5.2 Calculation for Auxiliary Boilers. Calculations are made by Following Equations:

Maneuvering Mode:

Using equation (3.4)

$E_{one\text{-}way}$ = 252 kW x (7.5nm/11 knot) hour x 994.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.17 tonnes CO_2E

$E_{maneuvering}$ = 0.17 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 65.64 tonnes CO_2E

Hoteling Mode:

Using equation (3.5)

$E_{hotelling}$ = 252 kW x 21.5 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 5.39 tonnes CO_2E

$E_{total\text{-}boil}$ = 65.64 tonnes CO_2E +5.39 tonnes CO_2E

$E_{total\text{-}boil}$ = 71.02 tonnes CO_2E

Total carbon footprint for Cargo Ships:

$E_{total\text{-}cargo}$ = $E_{total\text{-}main}$ + $E_{total\text{-}aux}$ + $E_{total\text{-}boil}$

$E_{total\text{-}cargo}$ = 1700.3 tonnes CO_2E + 641.15 tonnes CO_2E + 71.02 tonnes CO_2E

$E_{total\text{-}cargo}$ = 2412.44 tonnes CO_2E

3.3.3.6 Calculation for Solid Bulk Carriers Carbon Footprint

To calculate carbon footprint of Solid Bulk Carriers there are several assumptions and datas that are shown in Table 3.6:

Table 3.6 Assumptions and datas (CFWG, 2010; HEC, 2011; Ritchie, et al., 2002; SCG, 2008, 2016).

	Unit			
Built Year		2000+		
Propulsion System		Medium Speed-Diesel		
Auxiliary Power System		Medium Speed-Diesel/Electric		
Transit Mode Distance	Nm	35		
Maneuvering Mode Distance	Nm	7,5		
Maneuvering Mode Speed	Knot	9		
Hostelling Time	hour	22		
Average MCR	kW	5720		
Average Max Speed Rate	Knot	14.2		
Average Sea-Speed	Knot	13.3		
		Main Engine	Auxiliary Engine	Auxiliary Boiler
Average Auxiliary Loads For Auxilary Engine(Transit)	kW		255	
Average Auxiliary Loads For Auxilary Engine(Maneuvering)	kW		675	
Average Auxiliary Loads For Auxilary Engine(Hotelling)	kW		255	
Average Boiler Loads(Transit)	kW			0
Average Boiler Loads(Maneuvering)	kW			109
Average Boiler Loads(Hotelling)	kW			109
Emission Factor	CO_2E/kW-hr	692.8	692.8	994.8
Load Factor (Transit)	-	0.8	0.13	
Load Factor (Maneuvering)	-	0.03	0.5	
Load Factor (Hoteling)	-	0	0.17	
Time(Transit Mode Distance/Sea-Spead)	hours	0.83		
Ship Number	per year	192	192	192
Legs/Visit	-	2	2	2

3.3.3.6.1 Calculation for Main Engines. Calculations are made by Following Equations

Transit Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 5720 kW x 0.8 x (35nm/13.3 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 8.34 tonnes CO_2E

$E_{transit}$ = 8.34 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 3203.62 tonnes CO_2E

Maneuvering Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 5720 kW x 0.03 x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.09 tonnes CO_2E

$E_{transit}$ = 0.09 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 38.04 tonnes CO_2E

$E_{total\text{-}main}$ = 3203.62 tonnes CO_2E + 38.04 tonnes CO_2E

$E_{total\text{-}main}$ = 3241.67 tonnes CO_2E

3.3.3.6.2 Calculation for Auxiliary Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 255 kW x (35nm/13.3 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.46 tonnes CO_2E

$E_{transit}$ = 0.46 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 178.52 tonnes CO_2E

Maneuvering Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 675 kW x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.39 tonnes CO_2E

$E_{maneuvering}$ = 0.39 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 149.6 tonnes CO_2E

Hotelling Mode:

Using equation (3.3)

$E_{hotelling}$ = 255 kW x 22 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 3.9 tonnes CO_2E

$E_{total\text{-}aux}$ = 178.52 tonnes CO_2E +149.6 tonnes CO_2E +3.9 tonnes CO_2E

$E_{total\text{-}aux}$ = 332.1 tonnes CO_2E

3.3.3.6.3 Calculation for Auxiliary Boilers. Calculations are made by Following Equations:

Maneuvering Mode:

Using equation (3.4)

$E_{one\text{-}way}$ = 109 kW x (7.5nm/9 knot) hour x 994.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.09 tonnes CO_2E

$E_{maneuvering}$ = 0.09 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 34.7 tonnes CO_2E

Hoteling Mode:

Using equation (3.5)

$E_{hotelling}$ = 109 kW x 22 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 2.4 tonnes CO_2E

$E_{total\text{-}boil}$ = 34.7 tonnes CO_2E +2.4 tonnes CO_2E

$E_{total\text{-}boil}$ = 37.1 tonnes CO_2E

Total carbon footprint for Solid Bulk Carriers:

$E_{total\text{-}solid}$ = $E_{total\text{-}main}$ + $E_{total\text{-}mane}$ + $E_{total\text{-}boil}$

$E_{total\text{-}solid}$ = 3241.67 tonnes CO_2E + 332.1 tonnes CO_2E + 37.1 tonnes CO_2E

$E_{total\text{-}solid}$ = 3610.8 tonnes CO_2E

3.3.3.7 Calculation for Dry Bulk Carriers Carbon Footprint

To calculate carbon footprint of Dry Bulk Carriers there are several assumptions and datas that are shown in Table 3.7:

Table 3.7 Assumptions and datas (CFWG, 2010; HEC, 2011; Ritchie, et al., 2002; SCG, 2008, 2016).

	Unit			
Built Year		2000+		
Propulsion System		Medium Speed-Diesel		
Auxiliary Power System		Medium Speed-Diesel/Electric		
Transit Mode Distance	Nm	35		
Maneuvering Mode Distance	Nm	7,5		
Maneuvering Mode Speed	Knot	9		
Hostelling Time	hour	22		
Average MCR	kW	5720		
Average Max Speed Rate	Knot	14.2		
Average Sea-Speed	Knot	13.3		
		Main Engine	Auxiliary Engine	Auxiliary Boiler
Average Auxiliary Loads For Auxilary Engine(Transit)	kW		255	
Average Auxiliary Loads For Auxilary Engine(Maneuvering)	kW		675	
Average Auxiliary Loads For Auxilary Engine(Hotelling)	kW		255	
Average Boiler Loads(Transit)	kW			0
Average Boiler Loads(Maneuvering)	kW			109
Average Boiler Loads(Hotelling)	kW			109
Emission Factor	CO_2E/kW-hr	692.8	692.8	994.8
Load Factor (Transit)	-	0.8	0.13	
Load Factor (Maneuvering)	-	0.03	0.5	
Load Factor (Hoteling)	-	0	0.17	
Time(Transit Mode Distance/Sea-Spead)	hours	0.83		
Ship Number	per year	192	192	192
Legs/Visit	-	2	2	2

3.3.3.7.1 Calculation for Main Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 5720 kW x 0.8 x (35nm/13.3 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 8.34 tonnes CO_2E

$E_{transit}$ = 8.34 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 3203.62 tonnes CO_2E

Maneuvering Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 5720 kW x 0.03 x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.09 tonnes CO_2E

$E_{transit}$ = 0.09 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 38.04 tonnes CO_2E

$E_{total\text{-}main}$ = 3203.62 tonnes CO_2E + 38.04 tonnes CO_2E

$E_{total\text{-}main}$ = 3241.67 tonnes CO_2E

3.3.3.7.2 Calculation for Auxiliary Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 255 kW x (35nm/13.3 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.46 tonnes CO_2E

$E_{transit}$ = 0.46 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{transit}$ = 178.52 tonnes CO_2E

Maneuvering Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 675 kW x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.39 tonnes CO_2E

$E_{maneuvering}$ = 0.39 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 149.6 tonnes CO_2E

Hotelling Mode:

Using equation (3.3)

$E_{hostelling}$ = 255 kW x 22 hour x 994.8 CO_2E/kW-hr

$E_{hostelling}$ = 3.9 tonnes CO_2E

$E_{total\text{-}aux}$ = 178.52 tonnes CO_2E +149.6 tonnes CO_2E +3.9 tonnes CO_2E

$E_{total\text{-}aux}$ = 332.1 tonnes CO_2E

3.3.3.7.3 Calculation for Auxiliary Boilers. Calculations are made by Following Equations:

Maneuvering Mode:

Using equation (3.4)

$E_{one\text{-}way}$ = 109 kW x (7.5nm/9 knot) hour x 994.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.09 tonnes CO_2E

$E_{maneuvering}$ = 0.09 tonnes CO_2E/kW-hr x 2 visit/legs x 192

$E_{maneuvering}$ = 34.7 tonnes CO_2E

Hoteling Mode:

Using equation (3.5)

$E_{hotelling}$ = 109 kW x 22 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 2.4 tonnes CO_2E

$E_{total\text{-}boil}$ = 34.7 tonnes CO_2E +2.4 tonnes CO_2E

$E_{total\text{-}boil}$ = 37.1 tonnes CO_2E

Total carbon footprint for Dry Bulk Carriers:

$E_{total\text{-}dry}$ = $E_{total\text{-}main}$ + $E_{total\text{-}aux}$ + $E_{total\text{-}boil}$

$E_{total\text{-}dry}$ = 3241.67 tonnes CO_2E + 332.1 tonnes CO_2E + 37.1 tonnes CO_2E

$E_{total\text{-}dry}$ = 3610.8 tonnes CO_2E

3.3.3.8 Calculation for Ro-Ro Ships Carbon Footprint

To calculate carbon footprint of Ro-Ro Ships there are several assumptions and datas that are shown in Table 3.8:

Table 3.8 Assumptions and datas (CFWG, 2010; HEC, 2011; Ritchie, et al., 2002; SCG, 2008, 2016).

	Unit			
Built Year		2000+		
Propulsion System		Medium Speed-Diesel		
Auxiliary Power System		Medium Speed-Diesel/Electric		
Transit Mode Distance	Nm	35		
Maneuvering Mode Distance	Nm	7,5		
Maneuvering Mode Speed	Knot	9		
Hostelling Time	hour	4		
Average MCR	kW	7105		
Average Max Speed Rate	Knot	16.5		
Average Sea-Speed	Knot	15.5		
		Main Engine	Auxiliary Engine	Auxiliary Boiler
Average Auxiliary Loads For Auxilary Engine(Transit)	kW		434	
Average Auxiliary Loads For Auxilary Engine(Maneuvering)	kW		1301	
Average Auxiliary Loads For Auxilary Engine(Hotelling)	kW		434	
Average Boiler Loads(Transit)	kW			0
Average Boiler Loads(Maneuvering)	kW			278
Average Boiler Loads(Hotelling)	kW			278
Emission Factor	CO_2E/kW-hr	692.8	692.8	994.8
Load Factor (Transit)	-	0.8	0.13	
Load Factor (Maneuvering)	-	0.03	0.5	
Load Factor (Hoteling)	-	0	0.17	
Time(Transit Mode Distance/Sea-Spead)	hours	0.83		
Ship Number	per year	193	193	193
Legs/Visit	-	2	2	2

3.3.3.8.1 Calculation for Main Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 7105 kW x 0.8 x (35nm/13.3 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 8.9 tonnes CO_2E

$E_{transit}$ = 8.9 tonnes CO_2E/kW-hr x 2 visit/legs x 193

$E_{transit}$ = 3432.3 tonnes CO_2E

Maneuvering Mode:

Using equation (3.1)

$E_{one\text{-}way}$ = 7105 kW x 0.03 x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.12 tonnes CO_2E

$E_{transit}$ = 0.12 tonnes CO_2E/kW-hr x 2 visit/legs x 193

$E_{transit}$ = 47.5 tonnes CO_2E

$E_{total\text{-}main}$ = 3432.3 tonnes CO_2E + 47.5 tonnes CO_2E

$E_{total\text{-}main}$ = 3479.8 tonnes CO_2E

3.3.3.8.2 Calculation for Auxiliary Engines. Calculations are made by Following Equations:

Transit Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 434 kW x (35nm/15.5 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.67 tonnes CO_2E

$E_{transit}$ = 0.67 tonnes CO_2E/kW-hr x 2 visit/legs x 193

$E_{transit}$ = 262.07 tonnes CO_2E

Maneuvering Mode:

Using equation (3.2)

$E_{one\text{-}way}$ = 1301 kW x (7.5nm/9 knot) hour x 692.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.75 tonnes CO_2E

$E_{maneuvering}$ = 0.75 tonnes CO_2E/kW-hr x 2 visit/legs x 193

$E_{maneuvering}$ = 289.9 tonnes CO_2E

Hotelling Mode:

Using equation (3.3)

$E_{hotelling}$ = 434 kW x 4 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 1.2 tonnes CO_2E

$E_{total\text{-}aux}$ = 262.07 tonnes CO_2E +289.9 tonnes CO_2E +1.2 tonnes CO_2E

$E_{total\text{-}aux}$ = 553.2 tonnes CO_2E

3.3.3.8.3 Calculation for Auxiliary Boilers. Calculations are made by Following Equations:

Maneuvering Mode:

Using equation (3.4)

$E_{one\text{-}way}$ = 278 kW x (7.5nm/9 knot) hour x 994.8 CO_2E/kW-hr

$E_{one\text{-}way}$ = 0.23 tonnes CO_2E

$E_{maneuvering}$ = 0.23 tonnes CO_2E/kW-hr x 2 visit/legs x 193

$E_{maneuvering}$ = 88.9 tonnes CO_2E

Hoteling Mode:

Using equation (3.5)

$E_{hotelling}$ = 278 kW x 4 hour x 994.8 CO_2E/kW-hr

$E_{hotelling}$ = 1.1 tonnes CO_2E

$E_{total\text{-}boil}$ = 88.9 tonnes CO_2E +1.1 tonnes CO_2E

$E_{total\text{-}boil}$ = 90 tonnes CO_2E

Total carbon footprint for Ro-Ro Ships:

$E_{total\text{-}roro}$ = $E_{total\text{-}main}$ + $E_{total\text{-}aux}$ + $E_{total\text{-}boil}$

$E_{total\text{-}roro}$ = 3479.8 tonnes CO_2E + 553.2 tonnes CO_2E + 90 tonnes CO_2E

$E_{total\text{-}roro}$ = 4123.1 tonnes CO_2E

Calculations were made for ships came into the port. Each ship of 6 kind have their own special datas and results. For each ship, visit legs assuming as 2 times and ship number per year were calculated from distrubition of ships that came into the port. According to calculations, container ships have the biggest carbon footprint. Calculations show us that passenger-cruise ships carbon footprint is bigger than ro-ro ships. Passenger-cruise ships carbon footprint almost two times more than ro-ro ships carbon footprint. Passenger-cruise ships carbon footprint rank number two and ro-ro ships carbon footprint rank number three. Solid and liquid bulk carriers have same amount of carbon emission and their carbon footprint rank number four. Cargo ships carbon footprint rank number five and their carbon footprint was calculated as 2412.44 tonnes CO_2E. Table 3.9 shows us carbon footprint of each ship per year.

Table 3.9 Carbon footprint summary table

Ship Type	**Carbon Footprint (year based)**
Container Ships	43728.8 tonnes CO_2E
Passenger-Cruise Ships	7557.3 tonnes CO_2E
Cargo Ships	2412.44 tonnes CO_2E
Solid Bulk Carriers	3610.8 tonnes CO_2E
Liquid Bulk Carriers	3610.8 tonnes CO_2E
Ro-Ro (coastal)	4123.1 tonnes CO_2E
TOTAL	65043.24 tonnes CO_2E

The global average carbon footprint is 10 tonnes CO_2E per family per year. An airplane. A person who is flight from İzmir to İstanbul has carbon footprint that is about 0.06 tonnes CO_2E (Lipasto, 2008). A person who is travel from İzmir to Çanakkale with car has carbon footprint that is about 0.044 tonnes CO_2E (The International Council on Clean Transportation (ICCT), 2014). It means a port management has equal carbon footprint with a small town that has 6500 house and passenger-cruise ship's yearly carbon footprint is bigger than a person's who is travelling with car from İzmir to Çanakkale 170000 times.

Trees and forests are very important to absorb CO_2. An hectar forest can absorb 5 tonnes CO_2E each year (Forestry Comission, 2016). In the light of this information, to reduce carbon footprint of x port management, we need about 13000 hectar forest. This results show us how big problem is carbon footprint of ports.

CHAPTER FOUR
CONCLUSION AND RECOMMENDATIONS

This study shows how important waste management in port is. Ships number are same almost each month and %47 of these gave wastes when they came into port. Ship generated wastes are analyzed in five categories which are bilge water, sludge, waste oil, wastewater and garbage. According to amounts of given wastes, garbage has highest amount. There are a lot of obligations and difficulties for waste management in ports and harbours. Recommendations about these subject are as follows:

- Every port management operation should prepare waste management plan.
- Regulations for waste management in ports is change always. Because of that changes about regulations are needed to be followed.
- To manage wastes of port managements should have well-organized environmental deparment.

Global warming and grennhouse effect are getting more important day by day. To prevent from these kind of environmental disasters we should have informations about these disasters causes. Carbon footprint is most important indicator of air pollutions. To decrease effect of global warming and greenhouse, carbon footprint should be calculated. Then we may know what we are deal with. Carbon footprint in ports was calculated for ships that approach the port. According to calculation ship generated carbon footprint is 65043.24 tonnes CO_2E per year. Container ships has the highest rate of carbon footprint which is 43728.8 tonnes CO_2E. Recommendations about decreasing carbon footprint in ports are as follows:

- Preparing carbon footprint inventory is the first step for decreasing.
- According to inventory calculations should be done.
- In the light of calculation results, precautions have to be planned and interference should start from source that has highest carbon footprint value.

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APPENDICES

Table 5.1 Internal inspectation report

INTERNAL INSPECTATION REPORT		
-FIRM INFORMATION		
Name		X PORT MANAGEMENT
Address		---
Town/County/Province		---
Tel - Fax		---
Email address		---
Tax Office and Tax Number		---
Area (m²)	Open	872.795
	Closed	29.205
	Total	902.000
Coordinate (UTM)		---
Location		
Personel	Administrative	-
	Engineer	-
	Technician	-
	Master	-
	Worker	-
	Total	-
Manner of Work		Continuous
Number of Shift		3
Economic Territory	NACE Code	52.22.06
	Name	Port and Waterway Management

<table>
<tr><td colspan="2">Subject of Production</td><td>There are no production activities</td></tr>
<tr><td rowspan="3">Capacity</td><td>Environmental Impact Assessment Report / Project Promotion File / Out of Scope Letter</td><td>The Firm is exempt from Regulation of Environmental Impact Assessment Report because of it built before regulations in force.</td></tr>
<tr><td>Environmental Permit and Licence</td><td>The Firm has Environmental Permit and Licence Document ------- dated about Noise Control, Air Emission and Waste Reception Facility</td></tr>
<tr><td>Capacity Report</td><td>There are no production activities in port. Because of that it is exempt from capacity report.</td></tr>
<tr><td colspan="2">Environmental Management System Document</td><td>The Firm has applied to take EMS document. Assessment process is in progress.</td></tr>
<tr><td colspan="2">Incentives and Rewards taken on Environment</td><td>The Firm has not incentive and reward about environmental activities.</td></tr>
<tr><td colspan="3">2- GENERAL INFORMATION ABOUT THE ORGANIZATION</td></tr>
<tr><td colspan="3">The firm carry on a business in … address, registered on … section number, … block number, … parcel number at the deed, on 902.000 m^2 total area. The firm that is owner of the above-stated location.</td></tr>
<tr><td colspan="3">3- STATUS OF FIRM ACCORDING TO ENVIRONMENTAL IMPACT ASSESSMENT REGULATION</td></tr>
</table>

The firm has exemption certificate for Environmental Impact Assessment Regulation. Because the firm went into action before 07/02/1993 and there is provisional article in Environmental Impact Assessment Regulation, which was published in the official gazette on 23 June 1997 and no 23028, and this article says that about if any firm went into action before 07 February 1993 this provision article isn't enforced for them.

4- STATUS OF ORGANIZATION ACCORDING TO ENVIRONMENTAL PERMIT AND LICENCE REGULATION

Appendix Content	Appendix	Appendix II
	Section Number	Article 10.6
	Activity Name	Ports and marinas (except fishing ports, ferry docks)
Environmental Permit / Environmental Permit and Licence Subject		The firm is obliged to environmental permit about Noise Control, Air Emission and it is obliged to environmental licenced about Waste Reception Facility
Temporary Activity Certificate Operations		The firm has Temporary Activity Certificate on … and … document no.
Environmental Permit / Environmental Permit and Licence Operations		The Firm has Environmental Permit and Licence Document ------- dated ------- numbered about Noise Control, Air Emission and Waste Reception Facility.

5- FIRM FLOW PROCESS CHART AND PROCESS SUMMARY

The port carry on a business about waste reception activities from ships which approach the port

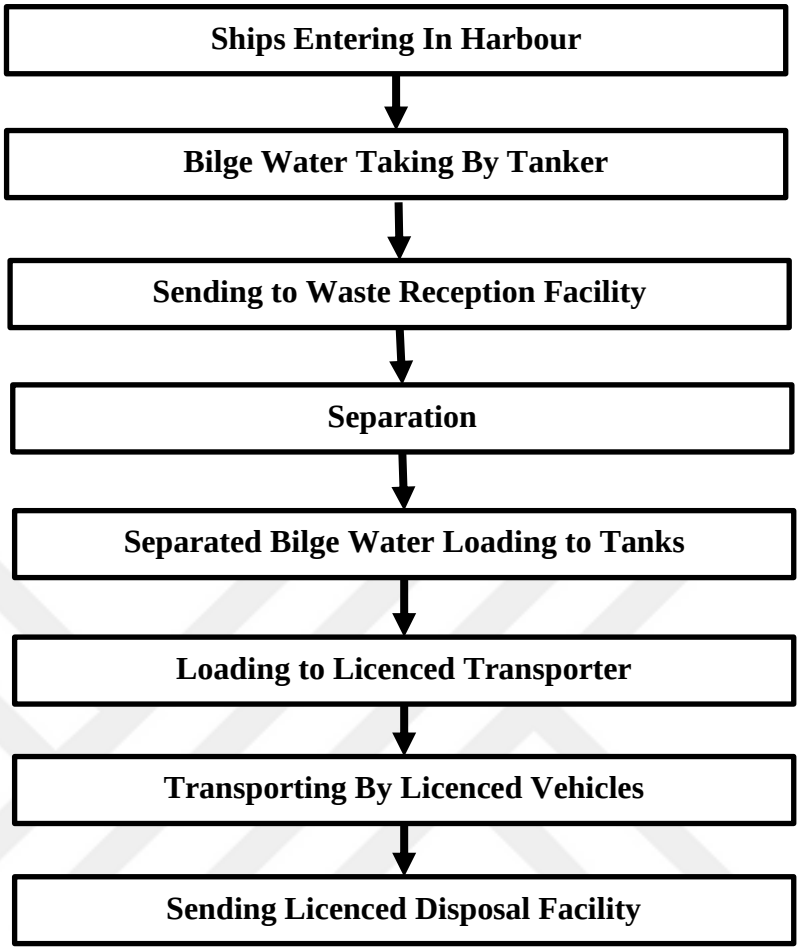
Amount and type of wastes from ships that are entered in harbour determine and report to Harbour Management. After that, wastes are taken with waste transfer form by authorized person of waste reception facility.

Wastes like bilge water and sludge are loaded in tanks of waste reception facility. Wastes like garbage and packing wastes are separated and collected in solid waste storage area.

Bilge water that was taken waste reception facility are sent to separator. After the separation process accure two kind of wastes as bilge water oil and waste water. Waste water are treated by chemical treatment system and are discharged.

According to national regulations bilge water and sludge are hazardous wastes. Because of that to dispose these wastes set up a commission. And they send to licenced facility to dispose.

Flow Process Chart of Disposal Process of Bilge Water



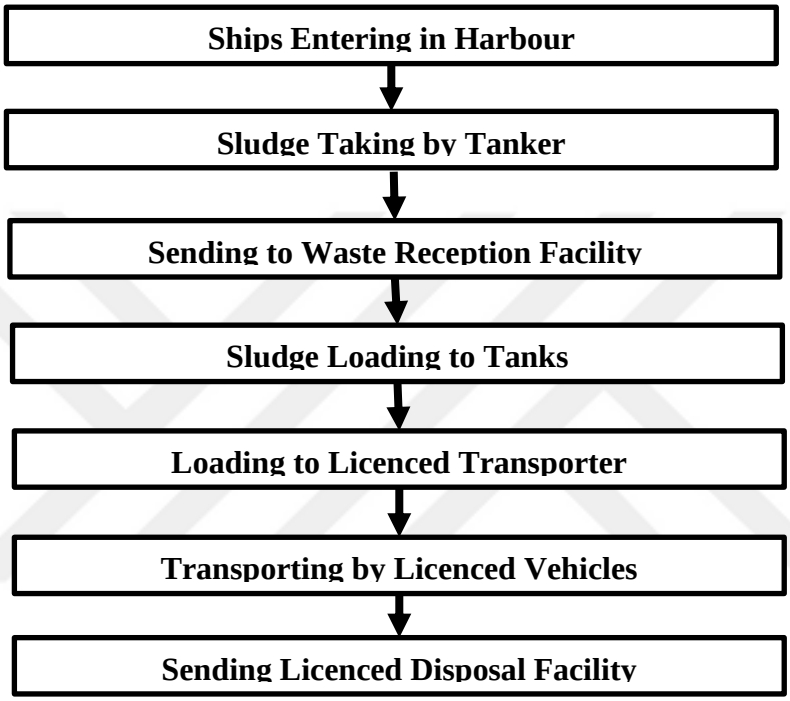
Explanation of Disposal Process of Bilge Water Flow Process Chart

Bilge water is generated by ship engine or cooling system of engine. It has %2 lubrication oil and fuel oil, %98 sea water and fresh water. It is collected a tank that is located in base of the ship.

Ships reports their wastes on waste tracking system of Ministry of environment and Urbanisation. After ship enter the harbour, authorized people of waste reception facility go to the ship in 1 hour maximum. Bilge water is taken by tanker and sent to the waste reception facility. Bilge water handed by tanker to facility is loaded in bilge water tank of waste reception facility. Authorized people prepare a waste transfer form for each ship and after finish the operation enter the ship waste tracking system.

Bilge water was taken are separated as waste water and oil. The Commission decide that time of disposal. Wastes are sent with licenced transporter to licenced disposal facility.

Flow Process Chart of Disposal Process of Sludge



Explanation of Disposal Process of Sludge Flow Process Chart

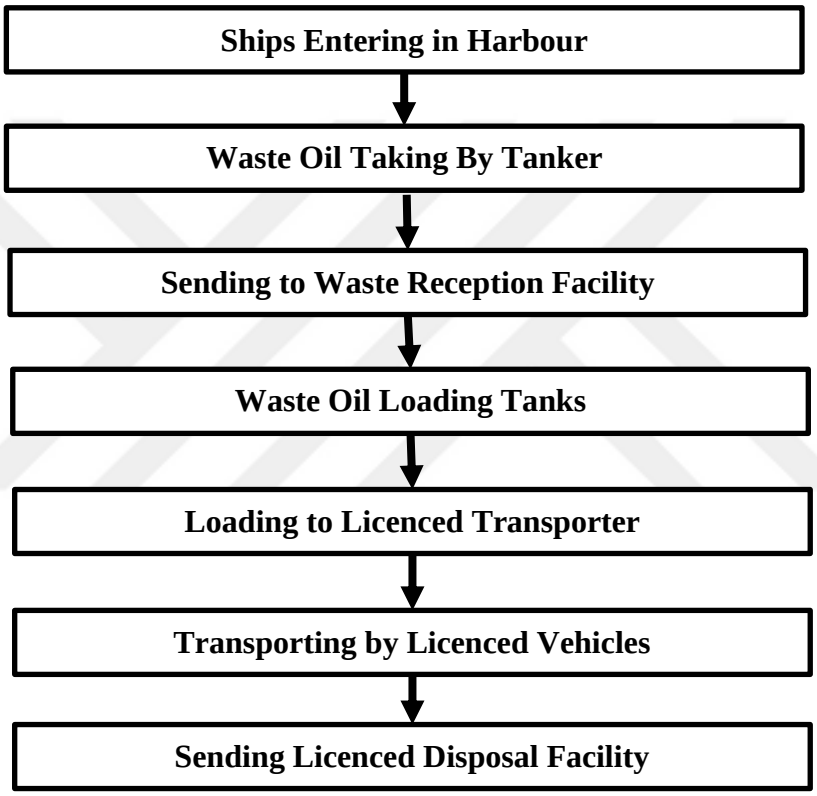
The heavy part of ship's fuel which is incombustible is collected as sludge. Ships that use heavy fuel oil collect %1-2 of their daily fuel oil, others collect %0,5 of their daily fuel oil as sludge. Generally, ships have sludge tanks which have 5-10 tones capacity. After 15-20 days navigation, tanks will be full. Sludge is high viscosity matter and it can turn into liquid form when it is heated.

Ships reports their wastes on waste tracking system of Ministry of environment and Urbanisation. After ship enter the harbor, authorized people of waste reception facility go to the ship in 1 hour maximum. Sludge is taken by tanker and send to the waste reception facility. Sludge handed by tanker to facility is loaded in sludge

tank of waste reception facility. Authorized people prepare a waste transfer form for each ship and after finish the operation enter the ship waste tracking system.

There isn't any special process for collected sludge. It is collected in sludge tank of waste reception facility. The Commission decide that time of disposal. Wastes are sent with licenced transporter to licenced disposal facility.

Flow Process Chart of Disposal Process of Waste Oil



Explanation of Disposal Process of Waste Oil Flow Process Chart

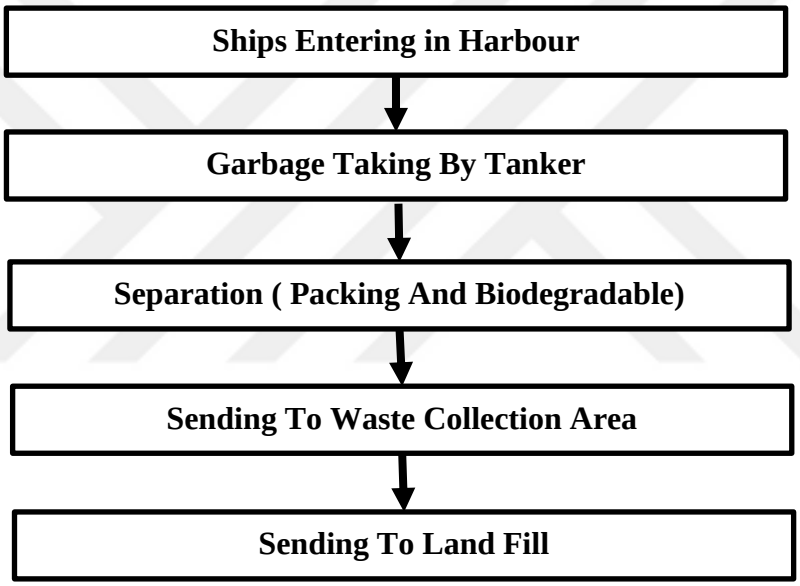
Waste oil occur when machine's oil is changed in ships. Waste oil amount show an alteration according to size of ships.

Ships reports their wastes on waste tracking system of Ministry of environment and Urbanisation. After ship enter the harbor, authorized people of waste reception facility go to the ship in 1 hour maximum. Waste oil is taken by tanker and send to

the waste reception facility. Waste oil handed by tanker to facility is loaded in waste oil tank of waste reception facility. Authorized people prepare a waste transfer form for each ship and after finish the operation enter the ship waste tracking system.

Waste oil hasn't water. Because of that, there is no need to separation process. Waste oil that is collected in waste oil tank of waste reception facility send to licenced disposal facility with licenced transporter. The Commission decide how and when is disposal.

Flow Process Chart of Disposal Process of Garbage



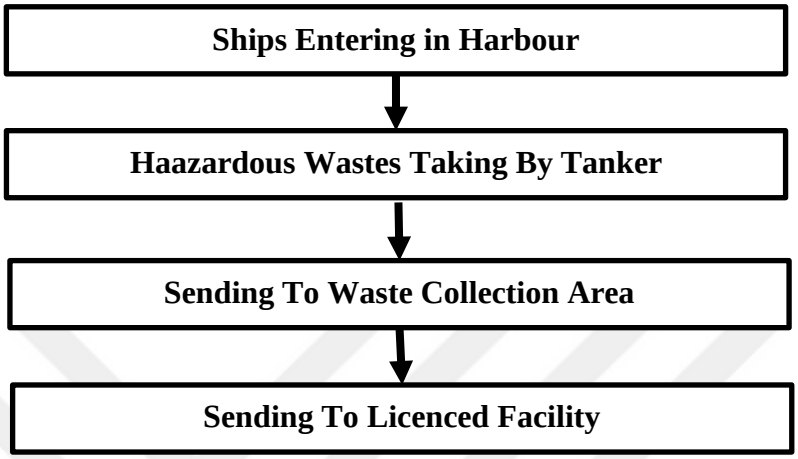
Explanation of Disposal Process of Garbage Flow Process Chart

Garbage means domestic waste which include food wastes, biodegradable wastes, packing wastes and nonhazardous wastes.

Generally, one person generates 3 kg garbage per day in ship. Garbage generated by ships generally include biodegradable and packing wastes. Packing wastes is separated from biodegradable wastes. Because, packing wastes are recyclable.

Garbage is taken from ships and send to waste collection area. Garbage that collected periodically send to city land fill.

Flow Process Chart of Disposal Process of Hazardous Wastes



Explanation of Disposal Process of Hazardous Wastes Flow Process Chart

A hazardous waste is a waste with a chemical composition or other properties that make it capable of causing illness, death, or some other harm to humans and other life forms when mismanaged or released into the environment. (EPA, 2005)

Ship generated hazardous wastes can include contaminated cloth, barrel contaminated with chemical matter etc. This kind of wastes are taken from ships and send to hazardous waste collection area. Like bilge water and sludge, hazardous wastes sent with licenced transporter to licenced disposal facility.

According to national regulations, hazardous wastes can be wait 6-month maximum. Maximum 6 months later hazardous wastes have to be sent to licensed disposal facility.

Flow Process Chart of Disposal Process of Waste Water

Ships Entering in Harbour

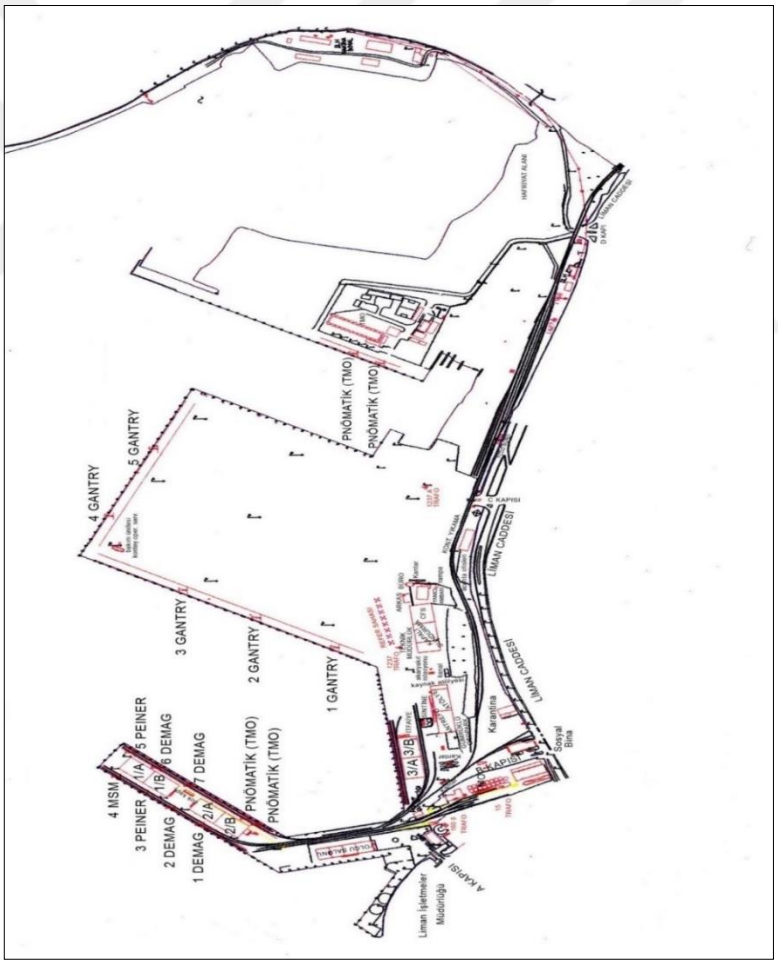
↓

Waste Water Taking By Tanker

↓

Discharging Into Sewage Of City

X Port Management location plan is as following



6- ASSESSMENT OF OPERATION ACCORDING TO ENVIRONMENTAL LEGISLATION

6.1.Environmental Auditing Regulation

The operation's activity which is ports and harbours management is in Appendix I of Environmental Permit and Licence Regulation. Because of that the operation has to get service about environmental consultancy from credentialed environmental firm in accordance with Environmental Auditing Regulation, which was published in the official gazette on 21 November 2008 and no 27061.

The firm has to sign a contract with credentialed environmental firm. Then this firm will be responsible of all kind of environmental work of the operation.

6.2.Environmental Permit and Licence Regulation

The operation's activity which is ports and harbours management is in Appendix I, Article 10.6 "Ports and marinas (except fishing ports, ferry docks)" of Environmental Permit and Licence Regulation, which was published in the official gazette on 10 September 2014 and no 29115. (Anonym, 2014). Because of this obligation the operation has Environmental Permit Certificate about Noise control, Air Emission and Licence Certificate about Waste Rception Facility … dated and … numbered.

6.3.Environmental Impact Assessment Regulation

There is a provisional article in Environmental Impact Assessment Regulation, which was published in the official gazette on 23 February 1997 and no 230028 which is about if any operation went into action before 07 February 1993 this regulation isn't enforced for them.

The operation has exemption certificate for Environmental Impact Assessment Regulation. Because of the operation carried on a business before 07 February 1993.

6.4.Regulation on Packaging Waste Control

In the port, ship generated packaging wastes accumulate in waste area. The operation has responsibility for disposal packaging wastes according to Regulation on Packaging Waste Control, which was published in the official gazette on 24 August 2011 and no 28035. The port management has to sign a contract with firm which is licenced about packaging waste collection and separation. The operation has to send a notice about amount and type of disposed packaging wastes on electronic system of Ministry of Environmental and Urbanization until the end of February each year.

6.5.Industrial Air Pollution Control Regulation

Dust emissions generate in port because of activities which is loading and unloading ships. Provincial Directorate of Environmental and Urbanization analyzed these activities according to Industrial Air Pollution Control Regulation, which was published in the official gazette on 03 July 2009 and no 27277. Then they gave letter of conformity. They indicate that measurement which is about dust emissions has to be made by laboratory that is accredited. The result of measurements was approved by Provincial Directorate of Environmental and Urbanization.

6.6.Regulation on Waste Management

Within the scope of Regulation on Waste Management, which was published in the official gazette on 02 April 2015 and no 29314 (Anonym, 2015) all kind of wastes codes and situations about being hazardous or not was analyzed and determined. In this contex, wastes is sent to licenced disposal facilities regularly according to their waste codes.

The operation collects all kind of wastes that is generated by port in waste collection area. Then all wastes are sent to licenced disposal facility according to their code.

Waste codes is determined in Appendix IV of Regulation on Waste Management. Codes of wastes which are generated by the operation are in the following table.

Codes of wastes which are generated by the operation are as following (Official Gazette, April 2, 2015 Number: 29314)

WASTE CODE	WASTE CODE DEFINITION	EXPLANATION
05 01 06*	Oily sludge generated by operation or equipment maintenance	A
15 02 02*	Absorbents, fitler materials (including oil filters not otherwise specified) wiping cloths, protective clothing contaminated by dangerous substances.	M
16 03 05*	Organic wastes that include hazardous substances	M
13 07 03*	Other fuels (including mixtures)	A
13 04 03*	Bilge water oils generated by other navigations	A
13 02 08*	Other lubricants, engine and transmission oils	A
13 05 06 *	Grease that is discharged by grease/waster separator	A
15 01 10*	Packaging containing residues of or contaminated by dangerous substances	A

Postscript
(*) Hazardous waste
(A) Hazardous waste
(M) The hazardousness situation of waste shall be determined.

6.7.Regulation of Soil Pollution Control and Point Source Contaminated Site

Regulation of Soil Pollution Control and Point Source Contaminated Site was published in the official gazette on 8 June 2010 and no 27605. Then this regulation revised and took his final form on 14 June 2012.

When analyzed the operation situation according to the Regulation of Soil Pollution Control and Point Source Contaminated Site, it was seen that there isn't the port activities in Appendix II of regulation.

6.8.Regulation of Avoiding and Reducing the Effects of Industrial Disaster

Regulation of Avoiding and Reducing the Effects of Industrial Disaster came into force on 30 December 2013.

By force of Regulation of Avoiding and Reducing the Effects of Industrial Disaster, every kind of operation has to report what kind of hazardous substances and their amounts. The operation report that online system called BEKRA. Reporting was made for port activities and result sheet sent to Provincial Directorate of Environmental and Urbanization.

6.9.Regulation of Assessment and Management of Ambient Noise

According to Environmental Permit and Licence Regulation, the operation is in Appendix II, Article 10.6. In accordance with this article the operation is exempt from Regulation of Assessment and Management of Ambient Noise, which was published on 04 June 2010 and no 27601 in official gazette.

The operation has already have Environmental Permit about Noise Control because of the regulation named Regulation On Permission And Licences Required By Environmental Law which is canceled on 1/11/2014.

Noise measurements has been made by accredited laboratory. The result of the measurements was sent to Provincial Directorate of Environmental and Urbanization with petition.

6.11. Water Pollution Control Regulations

The X Port Management is located in urban area. Because of that waste water generated by port activities is discharged in city sewage system. The operation has to actualized the discharge standard limits of water and sewerage administration.

Domestic waste water can be discharged directly on sewage system but other kind of waste water like cafeteria dishwater has to be treated before discharge. Because of that the operation has to made treatment system for this kind of waste water discharge. Otherwise water and sewerage administration can fine.

Authorized person from Water and Sewerage Administration can take sample random time of the year. The sample that is taken sent to their accredited laboratory and analyzed. According to result of analyze they fine or not.

Wastewater discharge standards to city sewerage system as following (Water And Sewerage Administration Of İzmir, 2016)

PARAMETER	UNIT	STANDARD VALUE
Temperature	^{o}C	40
pH		6.5 - 9
SS (Suspended Solid)	mg/L	350
Oil and Grease	mg/L	100
COD (Chemical Oxygen Demand)	mg/L	800
Free Chlorine	mg/L	5
As (Arsenic)	mg/L	3
Total (CN) Cyanide	mg/L	10
Pb (Lead)	mg/L	3
Total (Cr) Chromium	mg/L	5
Tar and Petrolium Grease	mg/L	50
Cl (Chloride)	mg/L	5000
Ag (Silver)	mg/L	5

The operation has to make an application to wastewater discharge to sewerage system. Application is evaluated by water and sewerage administration. Then if sample analyze result and application document is okay, they give the certificate named Sewage Connection Permit. This permission is active for 3 years. After 3 years it has to be renew.

6.1 WATER AND WASTEWATER DISCHARGE

6.1.1 Water Consumption	The port management use mains water system to water consumption, thanks to its location that is in urban area.
6.1.2 Domestic Wastewater	Domestic wastewater is generated by staff of port management. It comes from toilets and showers which is used by staff. Domestic wastewater also generated by ships. Because of the ship staff it generates. When ship come into port, it is given to waste reception facility, then discharge to city sewerage system.
6.1.3 Industrial Wastewater	There are 3 kind of industrial wastewater in port management. • Generated by waste reception facility • Generated by maintenance workshop • Generated by cafeteria Wastewater which is generated by waste reception facility is about 50 m^3/day. It is gone to chemical treatment system and then discharge to city sewerage system. Wastewater which is generated by maintenance workshop is about 10 m^3/day. It occur because of the maintanence activities which is use oil and

	grease. It is also treated by wastewater precaution system and discharge to city sewerage system. Wastewater which is generated by cafeteria activities that is dish washing etc. is treated by wastewater precaution system. That kind of wastewater include oil and food wastes in high quantity. All kind of industrial wastewater above-stated have to be treated before discharge to sewerage system. After the treatment it has to be suit to discharge standards of water and sewerage administration.
6.1.4 Rain and Wash Water	In port management rain water and wash water is collected by sewage system of port.
6.1.5 Wastewater Treatment Plant Informatıon	There are 3 wastewater treatment system in port management. **1) Waste Reception Facility Chemical Treatment System:** Wastewater occur because of separation process of bilge water or sludge. Bilge water or sludge is separated as grease and water. Water is given to chemical treatment system. Chemical Treatment System is consist of 12 units which are: • Balance Tank

	• pH Adjustment Tank I • ph Adjustment Tank II • Coagulation Tank • Lifting Tank I • Neutralization Tank • Flocculation Tank • Chemical Precipitation Tank • Lifting Tank II • Sludge Drying Tank • Sand Filter • Carbon Filter Industrial wastewater is treated in physical and chemical process. First of all, wastewater comes into balance tank. In pH adjustment tank, sulfuric acid dosing is made to wastewater and adjust pH value as 2.5. Then in pH adjustment tank, caustic dosing is made and pH value is adjusted as 5. After pH adjustment process wastewater flow into coagulation tank. Here, ferric chloride dosing is made and coagulation is occurred. Wastewater that is flew up from coagulation tank is lifted by wastewater lifting pump to neutralization tank. In this tank lime is dosed to wastewater and pH value is adjusted as 7-9. After neutralization tank wastewater flow flocculation tank. In this tank anionic polyelectrolyte is dosed to wastewater and flocs are occurred. From flocculation tank, wastewater flows by gravity to precipitation tank. Sludge precipitate in

	this tank and accumulate on the bottom of the tank. Spill water flows to lifting tank II and it is collected in here. Treated wastewater is lifted by lifting pump to sand and carbon filters. After filtration wastewater is discharged to city sewerage system. Precipitated sludge on the bottom of the precipitation tank is taken by valve to sludge drying tank. Sludge is dewatered in this tank. Filtrate water flows into balance tank. Dewatered sludge is sent to licenced disposal facility. Treated wastewater has to be proper to discharge to sewerage system according to discharge standard values. **2) Maintenance Workshop Wastewater Precaution System:** Port management has a maintenance workshop. In here, broken engines, equipment etc. is repaired. Because of this activity wastewater which include grease occur. Occurred wastewater is treated by wastewater precaution system and is discharged to city sewerage system Wastewater precaution system consist of 3 units which are: • Balance Tank

	• Precipitation Tank • Treated Wastewater Tank Wastewater that is generated by maintenance activities flows into balance tank. The aim of this tank is lifting wastewater to precipitation tank in stable flowrate. Wastewater that is accumulated in balance tank is lifted by lifting pump to precipitation tank. In precipitation tank, grease which is in wastewater rise to the surface and settleable solids precipitate on the bottom of the tank. Grease which is raised to the surface is stripped by mechanical stripper to grease barrel. Settleable solids which is accumulated on the bottom of the tank is taken by valve to solid barrel. Treated wastewater flows by gravity to sewerage system. **3) Cafeteria Wastewater Precaution System:** Wastewater generated by cafeteria activities is treated by wastewater precaution system before discharge to sewerage system. That treatment system is simpler than others. There is no mechanical equipment. This system is built under the ground. Aim of this system is separation process because of the oil which is in wastewater. Like grease oil also rise to the surface. Then it is stripped by attendant manually. Solids that is accumulated on the bottom is cleaned up periodically.

6.2 AIR MANAGEMENT

6.2.1 Information About Emission Source

Dust emissions generate in port because of activities which is loading and unloading ships. Provincial Directorate of Environmental and Urbanization analyzed these activities according to Industrial Air Pollution Control Regulation, which was published in the official gazette on 03 July 2009 and no 27277. Then they gave letter of conformity. They indicate that measurement which is about dust emissions has to be made by laboratory that is accredited. The result of measurements was approved by Provincial Directorate of Environmental and Urbanization

Mass flow of emissions and limit values of regulation are as following

EMISSION SOURCE	PARAMETER						
	CO	NO_2	NO	SO_2	DUST	VOC	OTHERS
External	-	-		-	0,96	-	-
TOTAL	-	-		-	0,96	-	-
LIMIT VALUES							
Appendix-3. d	5/50	-	20	60	10		
Appendix-2 flue	500	40	-	60	10		
Appendix-2 external	50	4		6	1		

6.2.2 Uncontrolled Emission Sources

There isn't uncontrolled emission sources in port management.

6.2.3 Confirm Measurement

Measurement of emission was made by accredited laboratory. The result of the measurements shows in following table.

<table>
<tr><td></td><td>Measurement Results are:

<table><tr><th>Measurement Point</th><th>Measurement Result (mg/Nm^3)</th><th>Limit Values (mg/m^3)</th></tr><tr><td>Point I</td><td>1.479</td><td>3</td></tr><tr><td>Point II</td><td>1.842</td><td>3</td></tr></table></td></tr>
<tr><td>6.2.4 Measurements For Internal Monitoring</td><td>There aren’t any measurements for internal monitoring</td></tr>
<tr><td>6.2.5 On-site Roads</td><td>To decrease emission of dust, on-site roads are controlled regularly.</td></tr>
<tr><td colspan="2">6.3 WASTE MANAGEMENT</td></tr>
<tr><td>6.3.1 General Wastes</td><td>Type wastes generated by port activities is as follows:

• Garbage
• Packaging wastes
• Hazardous wastes
• Waste water

Also there are wastes that is generated by ships and sent to waste reception facility:

• Bilge Water
• Sludge
• Waste Oil
• Garbage
• Hazardous Wastes
• Wastewater</td></tr>
</table>

6.3.2 Process Wastes	Process wastes that is generated was categorized in chapter 6.6
6.3.3 Waste Analysıs	There is no analyze that was made.
6.3.4 Waste Management Plan	Waste Management Plan was made by environmental consultancy firm. WMP was sent to Provincial Directorate of Environment and Urbanization.
6.3.5 Decleration Related to Wastes	According to Regulation on Packaging Waste Control, which was published in the official gazette on 24 August 2011 and no 28035, packaging waste notification has to be made by environmental consultancy firm until end of the February. Because of that, notifications have been made and sent to Provincial Directorate of Environment and Urbanization.
6.3.6 Liability Insurance	The port management have to make liability insurance.
6.4 NOISE MANAGEMENT	
The operation exempts from Regulation of Assessment and Management of Ambient Noise now. But noise measurements were made by accredited laboratory and results were sent to Provincial Directorate of Environment and Urbanization. The Operation has Environmental Permit about Noise Control.	
6.6 CHEMICALS MANAGEMENT	
6.6.1 Safety Data Sheet	Safety data sheets of chemicals that is used by port management was obtained from suppliers.
6.6.2 Chemical Storage/Usage	All chemicals that is used by port management is storage in an area which is approved by Health and Safety Regulations

<table>
<tr><td>6.6.3 Notifications About Chemicals</td><td>Regulation on Avoiding and Reducing the Effects of Industrial Disaster, notifications about chemicals has been made on BEKRA system. The result sheet was sent to Provincial Directorate of Environment and Urbanization.</td></tr>
<tr><td colspan="2">6.7 SHORE FACILITIES</td></tr>
<tr><td>6.7.1 Emergency Plan</td><td>Emergency Plan has been made by academic institution.</td></tr>
<tr><td>6.7.2 Liability Insurance</td><td>The port management have to make liability insurance.</td></tr>
<tr><td>6.7.3 Waste Reception Facility</td><td>The operation has waste reception facility. Environmental Permit and Licence about Waste Reception Facility was taken from Ministry of Environment and Urbanization.
Tank capacity of waste reception facility shows following table:

Capacity of waste reception facilty is shown as following

<table>
<tr><th>UNIT</th><th>QUANTITY</th><th>CAPACITY</th></tr>
<tr><td>Area of Waste Reception Facility</td><td>1</td><td>1120 m^2</td></tr>
<tr><td>Safety Pool</td><td>1</td><td>-</td></tr>
</table>
</td></tr>
</table>

	Bilge Water Tank	2	240 m^3
	Dewatered Bilge Water Tank	1	100 m^3
	Sludge Tank	3	360 m^3
	Dewatered Sludge Tank	2	200 m^3
	Waste Oil Tank	1	50m^3
	Toxic Liquid Wastes Tank	1	120 m^3
	Wastewater Discharged from Separator Tank	1	50 m^3
	Garbage Area	1	1.248 m^3

6.8 ENVIRONMENTAL AUDITING

There are not any environmental auditing that is made recently

6.9 ENVIRONMENTAL INVESTMENTS AND IMPROVEMENTS

Waste reception facility has been renewed. New facility is much more delicate, modern and easy to operate.

7 – ACCIDENTS AND LEAKAGES

7.1 Accidents and Leakages	There is not any accident or leakage in this period.

7.2 Failure, Maintenance and Repair	There is not any action about failure, maintenance and repair in this period.
8 - COMPLAINTS	
8.1 Transmitted Complaints to the Operation	There is not any transmitted complaints to the operation in this period.
8.2 Transmitted Complaints to Ministry	There is not any transmitted complaints to ministry in this period.
9 - TRAININGS	
9.1 Trainings	Training was made about Wastes that is generated by the operation and their disposal process.
9.2 Awareness Studies	Environmental Training was made to increase awareness of environmental.