BALAST TANKI SEDİMANLARININ KARADA YÖNETİMİ - ALTERNATİF BERTARAF METOTLARININ DEĞERLENDİRİLMESİ

MANAGEMENT OF BALLAST TANK SEDIMENTS ON LAND – EVALUATION OF ALTERNATIVE DISPOSAL METHODS

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TECHNICAL ASSISTANCE FOR CAPACITY BUILDING FOR PREVENTION OF MARINE POLLUTION CAUSED BY SHIP-SOURCED WASTES (2015-2017)

With the coordination of
Republic of Turkey Ministry of Environment Urbanization and Climate Change
The Project is supported by EU -IPA programme and conducted by under the leadership of SWECO, Turkey

TÜBİTAK MARMARA RESEARCH CENTER – Environment Institute
Sediment Management Studies
Determination of appropriate management methodologies that can be applied from sediment removal from the tank to its disposal



PURPOSE AND SCOPE OF THE STUDY

Ballast Water Convention

Article 5(1) of the Convention deals with sediment management and obligates the Parties to establish and operate sediment reception facilities.

Purpose and Scope

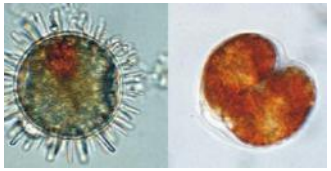
Characterization studies are carried out on sediments taken from ships' ballast tanks in shipyards that perform ballast tank cleaning and repair;

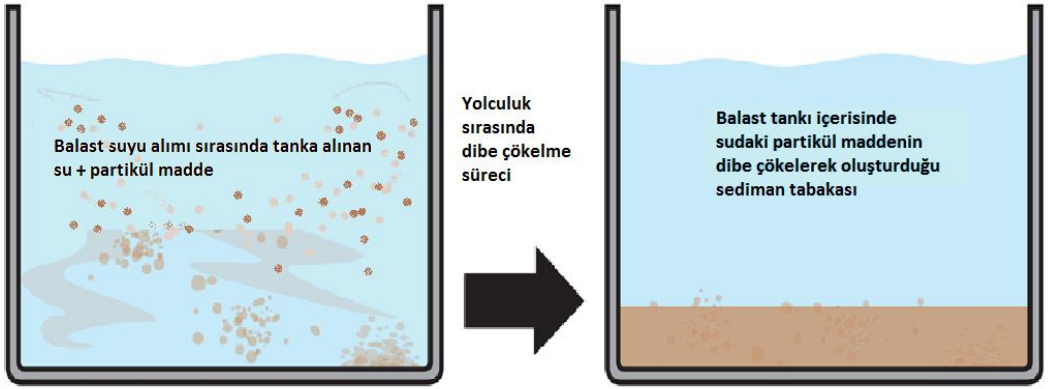
- Determination of appropriate management methodologies that can be applied from sediment removal from the tank to its disposal
- Evaluation of suitability for reuse and beneficial use technologies
- Determining the most appropriate disposal methodology

The study was conducted on sediment samples obtained from Shipyards in Tuzla, with the support of the Environmental Coordination Unit of GİSAŞ Shipbuilding Industry Inc.

BALLAST TANK SEDIMENTS

Ballast water: WATER + SUSPENDED SOLIDS





BIOLOGICAL CONTENT

- Resting forms of some organism
- Toxic dinoflagellate cysts
- Bacterial cysts and spores
- Eggs of some organisms, etc.

CHEMICAL CONTENT

- PAH, Heavy Metal, PCB
- Contaminants such as tank coating, paint chips or rust that spill/mix into the sediment layer from the tank walls

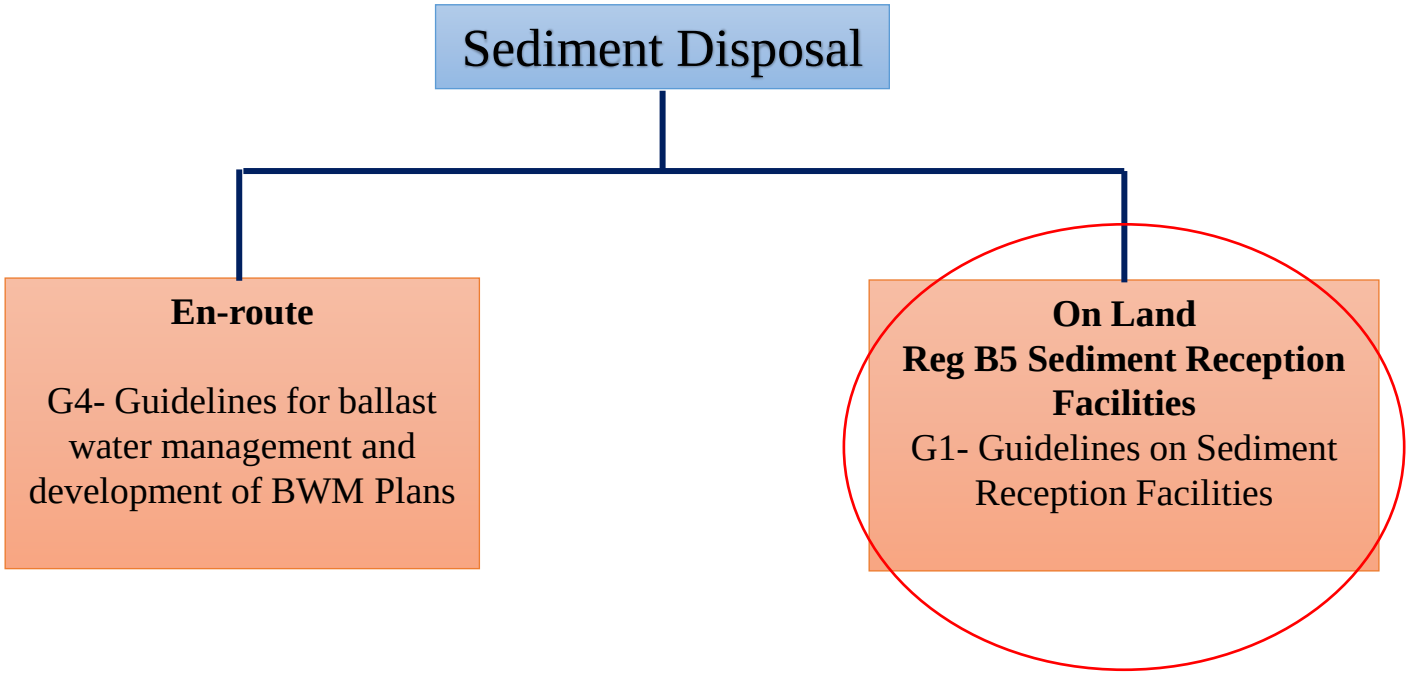
BALLAST WATER CONVENTION- SEDIMENT MANAGEMENT

Regulation B-5 *Sediment Management for Ships*

- ✓ Sediments management must be included in a ship's overall Ballast Water Management Plan

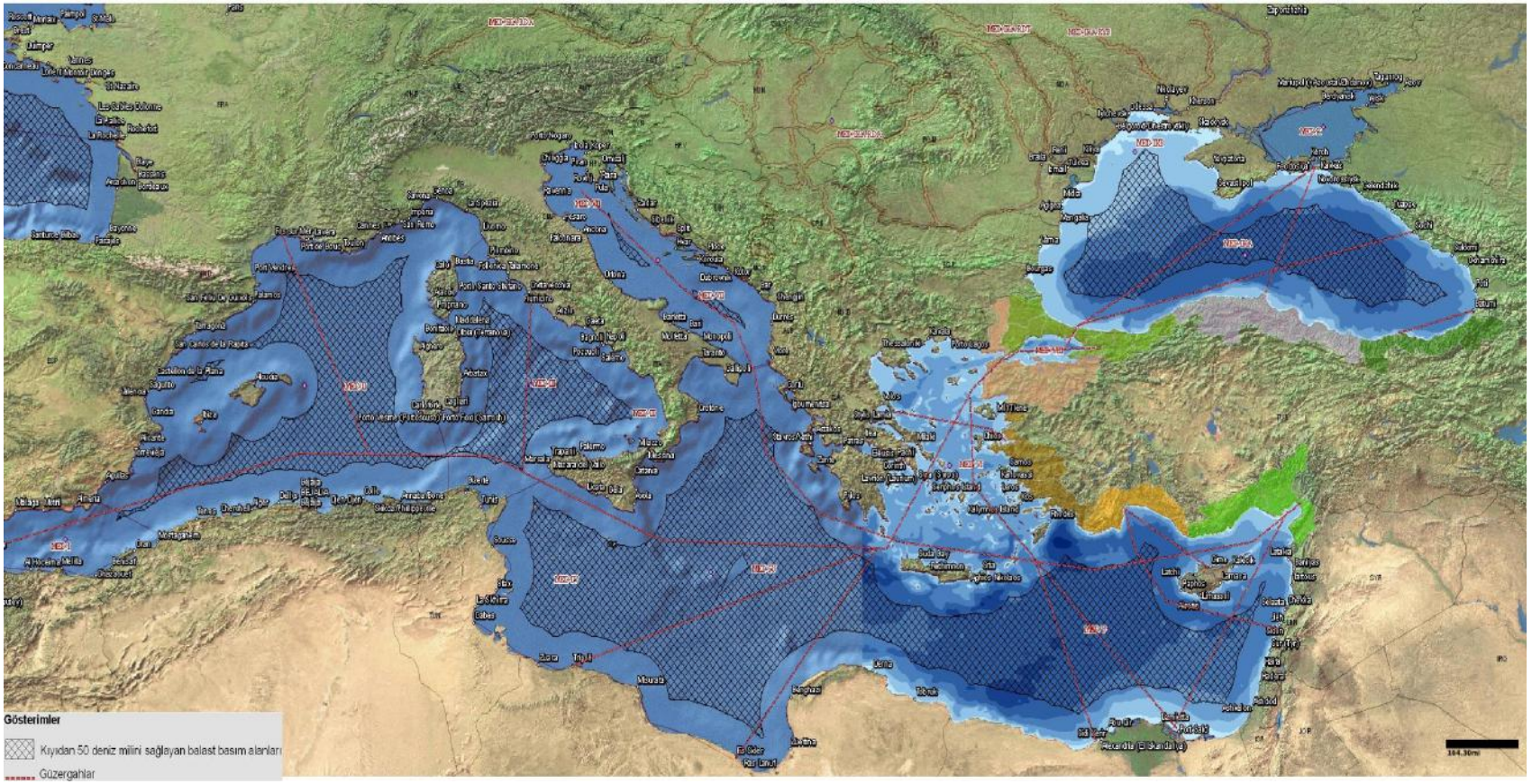
- ✓ New ships shall be designed and constructed in a way as to minimise the sediment intake into the ballast tanks and to prevent sediment accumulation in accordance with the related guidelines (G12) developed by IMO and facilitate sediment removal from the tanks and provide safe access to collect sediment samples.

SEDIMENT MANAGEMENT



SEDIMENT MANAGEMENT EN-ROUTE

Sediment disposal en-route should only be carried out at a distance of at least 200 nautical miles from the nearest land and at a depth of 200 m



TÜBİTAK MAM – Balast Suyu Yönetimi Projesi (2006 -2008)

GUIDELINES FOR SEDIMENTS RECEPTION FACILITIES –G1

The location and capacity information of the Sediment Reception Facility/Facilities is reported to the IMO

Countries that have regulations/legislation regarding waste disposal will dispose of sediment waste in accordance with their own legislation

Regional, national and local legislation which will affect the facility and related to the items below;

- ✓site selection
- ✓collection, handling and transport of sediment
- ✓sampling, testing and analysis of sediment
- ✓storage conditions
- ✓estimated required capacity (volume/weight) including moisture content of the sediment the facility will handle
- ✓environmental benefits and costs
- ✓effects on the environment in construction and operation of the facility
- ✓training of facility staff
- ✓equipment required to off load sediment from ships, such as cranes
- ✓human health and safety
- ✓Maintenance
- ✓operational limitations; and
- ✓waterway access, approaches and traffic management

For selection of the locations

- Accessibility and practicality
  - Establishment in shipyard areas where ships are most commonly used, where the highest maintenance and repair activities are conducted, and orientation towards regional services
  - The transportation distance from the facility to the waste recovery/disposal facility should be economically and physically suitable, without increasing disposal costs
  - Avoidance of causing environmental and water pollution, considering other environmental dimensions
  - Not being affected by meteorological conditions
  - Distance from densely populated working and settlement areas in the region
  - Having the capacity to provide the necessary workforce, expertise, and infrastructure support
  - Availability of a suitable vacant area that meets these conditions.

SEDIMENT VOLUME

Data obtained from regularly kept records regarding the amount of sediment taken from ships should be taken into account in determining the facility capacity.

Sediment volumes in ships' ballast tanks are highly variable

In the literature regarding the volume of sediment accumulated in ballast tanks, ranging from 20 tons to 670 tons.

The amount of sediment formation in ship's ballast tanks is directly related to;

- Port type
- Ballast water management practices
- Ballast tank design and configuration,
- The frequency in which ballast is taken onboard,
- The frequency of sediment removal

BALLAST WATER TREATMENT TECHNOLOGIES - ASSESSMENT ON SEDIMENT ACCUMULATION

- In BW treatment systems without particle removal (without filtration), sediment build up in the tank will continue.

- Most sediment material found in ships' ballast tanks is composed of fine-grain particles smaller than 50 µm, mostly < 35 µm. Therefore, utilizing filtration as a BWM Treatment will not preclude sediment accumulation in ballast tanks unless the filters can remove particles less than approx. 35 µm.

EFFECT OF BALLAST WATER TREATMENT TECHNOLOGIES ON SEDIMENT CONTENT

Biological Content
Sediments from ships that use the treatment system effectively and correctly will have no living content or will be of negligible value.

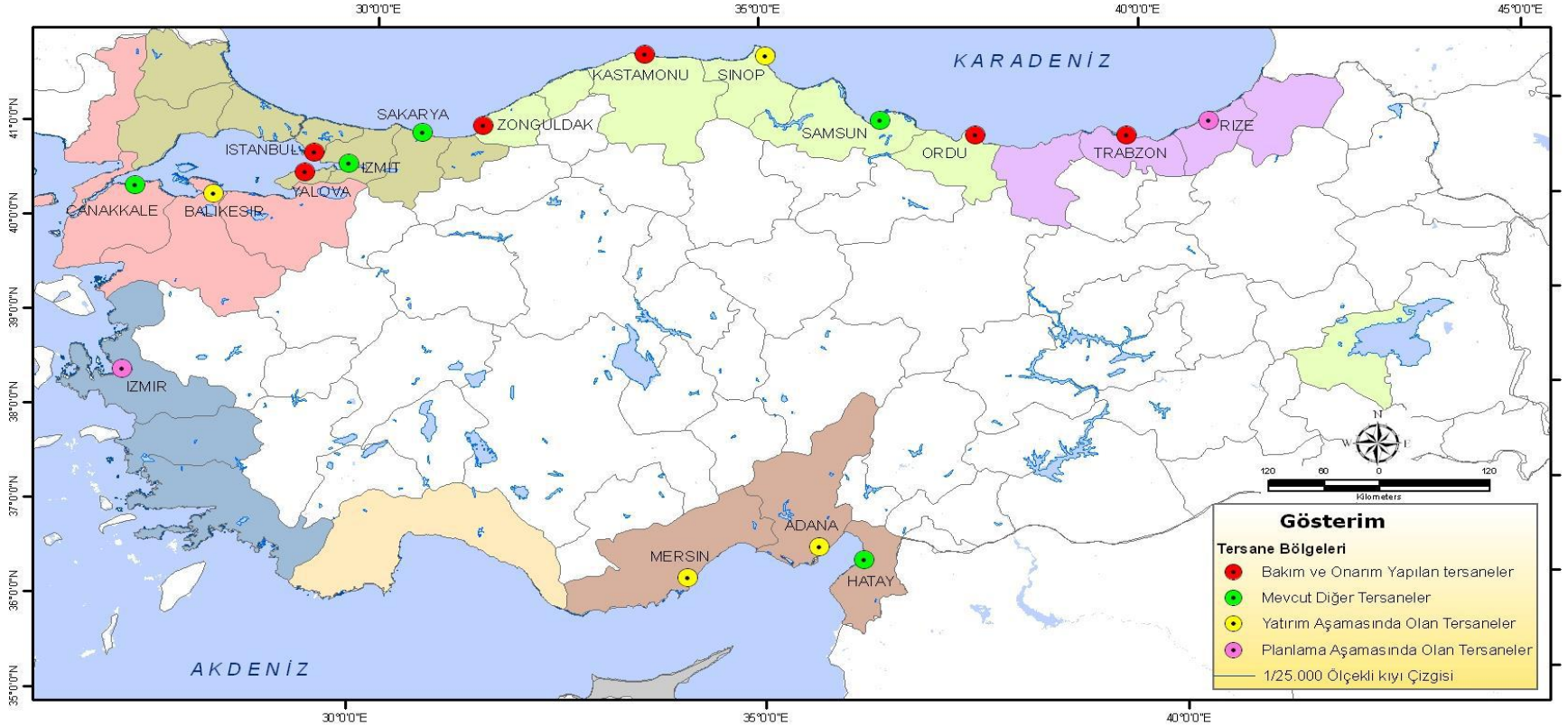
- Biocides used for disinfection purposes;
  - ✓with oxidizing compounds such as chlorine, chlorine dioxide, ozone, bromine, hydrogen peroxide and peroxyacetic acid;
  - ✓non-oxidizing compounds such as formaldehyde, glutaraldehyde, ammonium salts, various organosulfur compounds, dibromnitrile-propionamide
- By-products; It is genotoxic, carcinogenic and toxic.

Although Biocides approved by the IMO-GESAMP group are used in treatment systems, the effects of unconscious use and long-term accumulation of biocides should be taken into consideration.

SEDIMENT CHRACTERIZATION STUDY

Sediment samples from 6 different ships obtained from shipyards in Tuzla were provided.

- Possible risks of sediment on the environment and human health
- Characteristics as waste, is it possible to reuse, to get energy by burning??
- Determining the most appropriate disposal management
- Availability and cost of disposal method



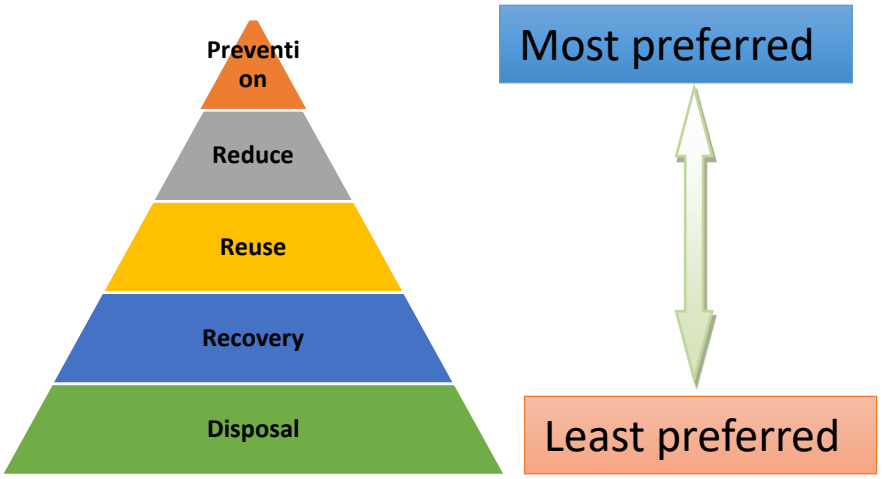
ALTERNATIVE METHODS EVALUATED FOR SEDIMENT WASTE

Reuse - Beneficiary use

use as aggregate material, which forms the raw material of concrete

Recovery - Obtaining energy by burning

Disposal- Landfill



NATIONAL LEGISLATION ON SEDIMENT DISPOSAL

Environmental Law

According to the Environmental Law No. 2872 any substance created as a result of any activity, released into the environment is defined as "waste".

According to provision of Article 11 of the Law

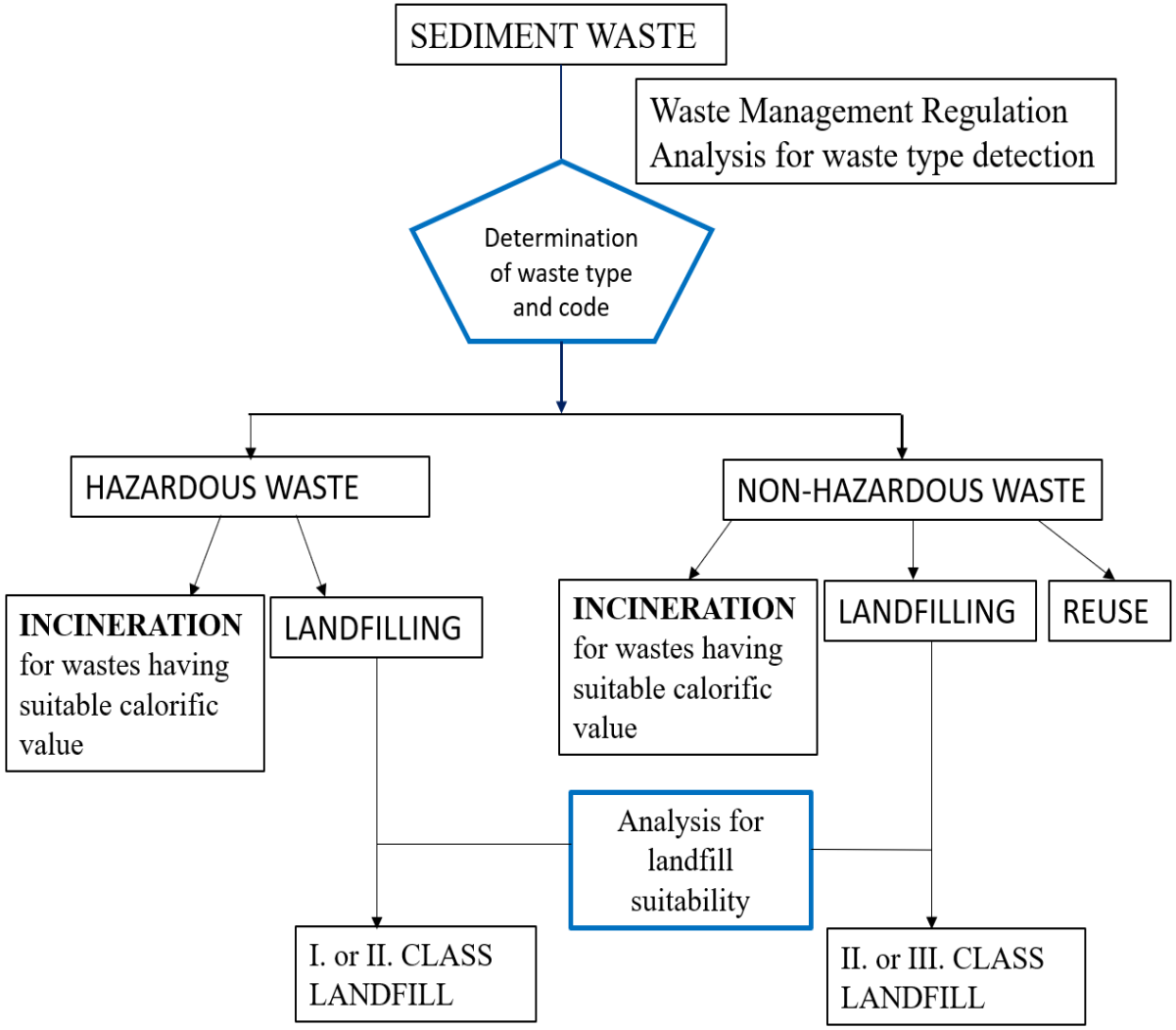
Coastal facilities such as ports, shipyards, ship maintenance-repair, ship dismantling, marinas are obliged to carry out the operation related to..

- storage, transportation and disposal of oily, oily solid wastes and liquid wastes such as bilge, dirty ballast, sludge, slop, domestic wastewater and solid waste generated in their own facilities and on ships and other marine vessels.
- or have facilities constructed for the reception,

NATIONAL LEGISLATION ON DETERMINATION OF THE WASTE CHARACTER OF SEDIMENT AND DISPOSAL

RELEVANT LEGISLATION

- Waste Management Regulation
- Regulation on Landfilling of Wastes
- Law on Metropolitan Municipalities



ANALYSES -WASTE MANAGEMENT REGULATION-ANNEX 3B

Parametre	Analiz Yöntemi
Fizikokimyasal analiz yöntemleri	
Görünüm/koku	Duyusal
pH Değeri (sulu çözelti)	TS 8753 EN 12176 (pH değerinin tayini)
Çözünmüş Oksijen (sulu çözelti) (mg/l)	SM-4500 OG
İletkenlik (sulu çözelti) (mS/cm)	TS ISO 11265 - Toprak Kalitesi – Elektriksel Özileteknlik Tayini
Nem (su) İçeriği (%ağırlık)	TS 9546 EN 12880 / Nisan 2002 (kuru kalıntı ve su muhtevası tayini)
Katı Madde İçeriği (%ağırlık)	TS 9546 EN 12880 / Nisan 2002 (kuru kalıntı ve su muhtevası tayini)
Organik Madde Miktarı (%ağırlık)	TS 8336 (organik madde tayini)
İnorganik Madde Miktarı (%ağırlık)	TS 8336 (organik madde tayini)
Organik Madde Cinsi	EPA 8260 GC-MS (hekzan özütlemesi) ASTM E1252 FTIR spektrofotometre
İnorganik Madde Cinsi	X Işını Difraksiyonu (XRD), (PDF: Toz difraksiyon kart numarası) X-Işını Floresan Spektroskopisi (XRF)
Yağ-gres (mg/kg)	SM-5520 F Soxhlet Ekst.
Birim ağırlık (kg/m^3) (ıslak ve kuru)	TS EN 1097-6:2002
Tane boyutu dağılımı (%)	Yaş elek analizi ve hidrometre
Toplam Kükürt (%ağırlık)	ASTM D 4239-05
Üst Kalorifik Değer (kcal/kg) (kuru baz)	ASTM D5865
Dioksinler/Furanlar (PCDD/F ng/kg I-TEQ)	EPA 1613 (GC-HRMS)
Poliaromatik hidrokarbonlar (PAH mg/kg)	ISO 11338-2 (GC-MS)
Poliklorlu bifeniller (PCB mg/kg)	ISO 10382 (GC-ECD), EPA 3540C
BTEX (benzen, toluen, etilbenzen ve ksilen) (mg/kg)	EPA 8015C (Headspace GC-MS)
Pestisitler (klorlu/fosforlu) (mg/kg)	EPA 8081, EPA 8141 (GC-MS)
Tributilkalay (mg/kg)	In-house metod (LC-MSMS)
Ağır Metallar (Pb, Cd, Cr, Cu, Ni, Zn, Hg, As) (mg/kg)	ISO 11885, EPA 7473
Toksikolojik Analiz Yöntemleri	
Ekotoksisite	ISO/EN/DIN 11348
Akut toksisite (Farelerde)	Acute Oral Toxicity-Fixed Doze, OECD TG 423
Akut toksisite (Balıklarda) (Balık biyodeneyi (ZSF))	AB 92/69/EEC Method C1

Analysis and tests carried out to determine the hazardous waste characteristics in determining the disposal methodology of the sediment;

- Particle size distribution analysis
- Physicochemical analyses
- Organic content analyses
- Inorganic content analyses
- Ecological toxicity tests

ANALYSES - WASTE MANAGEMENT REGULATION-ANNEX 3B

- Physicochemical analyses

Parameter	Result	Analysis Method
Physical Properties		
Appearance/Odour	Brown/Odour-free	Visual/Sensual
Moisture content (weight%)	57,63	TS 9546 EN 12880:2002
Solids content (weight%)	42,37	TS 9546 EN 12880:2002
pH value (aqueous solution)	7,84	TS 8753 EN 12176
Conductivity (aqueous solution)	18,27	SM-2510 B
Unit weight (g/m^3) (dry)	0,96	TS EN 1097-6:2002
Chemical Properties		
Organic substance amount (weight%)	3,09	TS 8336
Inorganic substance amount (weight%)	39,28	TS 8336
Upper calorific value * (kcal/kg)	No measurement	ASTM D 5865-13
Total sulphur* (%)	0,15	ASTM D4239
Oil-grease (mg/kg)	821	SM-5220 B Open reflux
Nitrogen (mg/kg)	1079	SM-4500 N
Phosphorus (mg/kg)	948	SM-4500 P
Total Dissolved Solids (mg/l)	6634	SM-2540 C

- High water content
- Low organic and high inorganic contents
- No calorific value is related to very-low organic and oil/grease contents
- Conductivity >16 mS/cm; because of very high salt

ANALYSES -WASTE MANAGEMENT REGULATION-ANNEX 3B

ICP-OES Heavy Metal Analysis Results

Ağır Metal	Balast sedimanı (mg/kg)	Tehlike Sınıfı, Risk Kodları ve Tehlikeler	AYY EK3B Tehlikeli Atık Eşik Kons.
Fe	70756	F: R11 (H3A)	-
Pb	18,09	(-): R33 (-) Üre. Kat1,2: R61 (H10) Üre. Kat3: R62 (H10) Xn: R20/22 (H5) T+: R26/27/28 (H6) N: R50/53 (H14)	- %0,5 %5 %25 %0,1 -
Cd	0,21	T+: R26 (H6) Kans. Kat1,2: R45 (H7) Üre. Kat3: R62, R63 (H10) Muta. Kat3: R68 (H11) Xn, T: R48/23/25 (-) N: R50/53 (H14)	%0,1 %0,1 %5 %1 %3 -
Cr	134,02	F: R11 (H3A) Kans. Kat3: R40 (H7) N: R52 (H14)	- %1 -
Cu	80,21	F: R11 (H3A) N: R52 (H14) Xi: R36/37/38 (H4)	- - %20
Ni	37,04	Kans. Kat3: R40 (H7) Xi: R43 (H13) Xn, T: R48/23 (-) N: R52/53 (H14)	%1 %1 %3 -
Zn	3338	N: R50/53 (H14)	-
Hg	0,0541	T+: R26 (H6) Üre. Kat1,2: R61 (H10) Xn, T: R48/23 (-) N: R50/53 (H14)	%0,1 %0,5 %3 -
As	17,34	T: R23/25 (H6) N: R50/53 (H14)	%3 -
Al	50868	F: R15, R17 (H3A)	-

Detected heavy metal levels are below regulatory limit values

ANALYSES -WASTE MANAGEMENT REGULATION-ANNEX 3B

Persistent Organic Pollutant (POP)

Parametre	Sonuç	Tehlike Sınıfı, Risk Kodları ve Tehlikeler	AYY EK 3B Tehlikeli Atık Eşik Kons.	Analiz Metodu
PCDD/F (pg/kg I-TEQ)	1,28	Kans.Kat.3: R40 (H7)	%1	EPA 1613 (GC-HRMS)
PAH (mg/kg)	0,003	Kans.Kat.1,2: R45 (H7)	%0,1	ISO 11338-2 (GC-MS/MS)
PCB (mg/kg)*	0,0037	Üre.Kat.1,2: R61 (H10)	%0,5	ISO 10382 (GC-MS/MS)
Toplam Klorlu Pestisit (µg/kg)	0,88	Xn: R20/21/22 (H5)	%25	ISO 10382 (GC-MS/MS)
Tributilkalay (µg/kg)	0,5	Xi (R36/37/38) (H4)	%20	İşletme içi metod (LC-MSMS)
		N: R50/53 (H14)	%0,25	

Detected POP levels are below regulatory limit values

ANALYSES WASTE MANAGEMENT REGULATION-ANNEX 3B

Semi-quantitative analysis results

Element	%ağ.	Element	%ağ.
Na	1,927	Ca	3,292
Mg	2,509	Ti	0,460
Al	7,837	Mn	0,119
Si	22,475	Fe	11,035
P	0,139	Zn	0,615
S	1,047	Rb	0,010
Cl	3,263	Sr	0,025
K	1,643	Zr	0,025

Inorganic structure do not pose a risk.

According to ISO/EN/DIN Eco-toxicity Analysis Result

EC 50 (%)	Toxicity Class	Result / Explanation
Not found	0	Not Eco-toxic

ToxAlert 100

ANALYSIS WASTE MANAGEMENT REGULATION-ANNEX 3B

Particle Size distribution of ballast sediment

	Particle size (distribution) (weight%.)				
	Pebble (> 2 mm)	Coarse Sand (2mm-200 µm)	Fine Sand (200µm-63 µm)	Silt (63µm-2 µm)	Clay (< 2 µm)
Ballast sediment	0	0	53,47	36,63	9,90

The dominant particle sizes of ballast sediment observed are "**Fine Sand**" and "**Clay-Silt Mixture**.

ANALYSIS FOR Regulation on LANDFILLING of WASTES

ANNEX 2: Acceptance criteria table for landfilling of wastes

- **Chloride (Cl)** concentration is confirmed **to exceed the limit value** given in the limit values table for **Class I landfills/storage facilities**
- 42,37% **solids content** of the ballast sediment sample is observed to be **below the 50% limit value of landfills.**

Parameter	Ballast sediment	RoLW/Annex-2 Storage/Landfill Criteria for Inert wastes Limit Values for Class III Storage Facilities/ Landfills	Storage/Landfill Criteria for Non-Hazardous wastes Limit Values for Class II Storage Facilities/Landfills	Storage/Landfill Criteria for Hazardous Wastes Limit Values for Class I Storage Facilities/Landfills	Method
Eluate Analysis Parameters (L/S=10 lt/kg)					
Arsenic (As mg/l)	0,0024	0,05	0,2	2,5	EPA
Barium (Ba mg/l)	0,050	2	10	30	6020A
Cadmium (Cd mg/l)	0,00015	0,004	0,1	0,5	
Chromium (Cr mg/l)	0,00072	0,05	1	7	
Copper (Cu mg/l)	0,0123	0,2	5	10	
Mercury (Hg mg/l)	<0,000014	0,001	0,02	0,2	SM 3112
Molybdenum (Mo mg/l)	0,0138	0,05	1	3	EPA
Nickel (Ni mg/l)	0,0011	0,04	1	4	6020A
Lead (Pb mg/l)	0,0031	0,05	1	5	
Antimon (Sb mg/l)	0,00042	0,006	0,07	0,5	
Selenium (Se mg/l)	0,0021	0,01	0,05	0,7	
Zinc (Zn mg/l)	0,071	0,4	5	20	
Chloride (Cl^- mg/l)	3090	80	1500	2500	SM-4110B
Fluoride (F^- mg/l)	<0,2	1	15	50	
Sulphate (SO_4^{2-} mg/l)	1202	100	2000	5000	
Dissolved organic carbon (DOC mg/l)	4,8	50	80	100	SM-5310B
Total dissolved solids (TDS mg/l)	6634	400	6000	10000	SM-2540C
Phenol index (C_6H_5OH mg/l)	<0,07	0,1	-	-	SM-5530D
Original Waste Analysis Parameters					
Total organic Carbon (TOC mg/kg)	10403	30000 (%3)	50000 (%5)	60000 (%6)	SM-5310B
BTEX (benzene, toluene, ethylbenzene and xylenes) (mg/kg)	<0,5	6	-	-	EPA 8015C
PCBls (mg/kg)	0,0037	1	-	-	ISO 10382
Mineral oil (mg/kg)	82	500	-	-	BS EN 14039
Loss on ignition (%)	3,09	-	-	100000 (%10)	TS EN 12879

CHARACTERIZATION FOR BURNING/INCINERATION

Brief analysis results (proximate analysis)

ANALYSES	UNIT	RESULTS		METHOD
		Original Based	Dry Based	
Moist	weight %	13,09	-	ASTM D 7582-15
Ash	weight %	77,17	88,78	ASTM E 1755-01 (Reapp.2007)
Volatiles	weight %	9,33	10,73	ASTM D 7582-15
Fixed Carbon	weight %	0,41	0,49	ASTM D 3172-13
Total Sulphur	weight %	0,15	0,17	ASTM D 4239-14
Upper calorific value	Weight cal/g	(-) no measurement	(-) no measurement.	ASTM D 5865-13

- Mostly ash (77.17%)
- Moist (13.9%)
- Fixed carbon 0.41%;
- Volatile matter 9.33%
  - An inorganic material
  - Energy value very low/none

Elementary/ultimate Analysis results

Analyses	Unit	Results (dry based)	Method
C (Carbon)	weight%	3,27	ASTM D 5373-14
H (Hydrogen)	weight%	0,48	ASTM D 5373-14
N (Nitrogen)	weight%	0,27	ASTM D 5373-14
S (Sulphur)	weight%	0,17	ASTM D 4239-14
Ash	weight%	88,78	ASTM D 7582-15
O (Oxygen)	weight%	7,03	ASTM D 3176-15

KEY FINDINGS

- ✓ Many different types of chemicals were detected in the sediment samples examined, the concentration values in the content are not at dangerous limits according to Waste Management Regulation

- ✓ Significant part of the sediment content is comprised of **fine sand (3.9–62.5 µm) and clay (0.98–3.9 µm)**, these types of particles have higher water retention capability and causes sludge formation

- ✓ **Very high-water content** (around 60%), while the dry matter amount is 40%

- ✓ 40% **dry matter content** of the ballast sediment sample is observed to be **below the 50% limit value of landfills.**

- ✓ **Chloride (Cl)** concentration is confirmed **to exceed the limit value** given in the limit values table for **Class I landfills/storage facilities**

- ✓ Inorganic material

- ✓ No calorific value is related to very-low organic and oil/grease contents

SUITABILITY FOR BURNING/INCINERATION

- ✓ In general, the burning/incineration process is a costly waste disposal method, but on the other hand it is one of the most efficient techniques
- ✓ t is not a flammable material because its organic content and oil-grease content is very low, and its inorganic content is very high.
- ✓ No calorific value
- ✓ Materials with high salt content are not preferred because they cause corrosion in combustion systems
- ✓ It is not considered technically and economically possible to mix and blend it with a different waste with high energy calorific value.

It is not a suitable material for generating energy by burning

SUITABILITY FOR BENEFICIAL USE

Properties of the sediment that make it unsuitable for beneficial use

- Since the dominant particle size of ballast sediment is fine sand and clay-silt, the sediment is not suitable for use as aggregate in practices like concrete, highway infrastructures and supra-structures, soil practices, geotechnical practices, fillings etc.
- Due to its high salinity, using ballast sediments as a filler material is highly risky. It is also not possible wash/sieve such a fine material at washing/sieving facilities.
- Since the ballast sediment amounts produced annually is also limited, pre-treatments required for re-use of this material will not be economically feasible at all.

SUITABILITY FOR LANDFILL STORAGE

The most appropriate disposal methodology for ballast tank sediments is landfill storage.

Providing that..

- ✓ The chloride (salt) and water content exceed the acceptance criteria for landfills / storage facilities.
- ✓ Pre-treatment processes such as solidification/stabilization are required for dehydration and reduction of chloride content.

- ✓ It is also possible to use Geotextile tubes for dewatering processes (high-strength polypropylene material - used in dewatering and disposal of sea-bottom dredging materials)

Teşekkürler…….