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Analysis of Polluted Oily Water Management in Klaipėda Sea Port

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Lithuania is one of the countries that have ratified the Marpol 73/78 Convention which foresees the tools of reduction and prevention of sea pollution with bilge water and other substances. The Directive of the European Parliament and Council 2000/59/EB is addressed to the reduction of waste on board of ships and its wash overboard..

Analysis of the ships entering Klaipėda Sea Port has estimated that oil waste comprises about 74 % of the whole collected waste amount. The analysis of technological flows and documents has indicated problematic points in the following processes:

1. collection of oily and engine bilge water from ships;
2. collection of spilled overboard oil products;
3. exploitation of intermediate accumulative reservoirs in the port;
4. regular transportation of accumulated oily water engine bilge water to the oil-polluted water treatment station;
5. distribution, storage, treatment (mechanical, physical, sorption) of pumped engine bilge water.

Among oil polluted waste, its specific kind – oily water emerges in ports and it is called "engine bilge water" in the Waste Management Regulations. Engine bilge water is specific and hazardous to the environment as it is a liquid compound of water and oil products capable of making steady emulsions. It also acquires specific properties during various technological processes. Equipment, technological processes, specificity of the control related to combustibility and inflammability, as well as conformity to the requirements of the International and EU Rights, technological processes management and documents are needed for the management of this specific waste. For this reason, separation of this oily water from the common oil-polluted waste and analysis of these streams of waste treatment are of great importance in enhancement of the effectiveness of environmental protection during the management process of this oily waste.

Applying a system approach to the oily waste in the port, a waste management system algorithm based on the life cycle has been set up. The system of port waste management is a set of technological processes, each of them performing a certain function and demanding for stock, electric energy, fuel, transport, heat, technological equipment, etc.

Having completed the analysis, the algorithm assessing the supervision of technological processes and documents of engine bilge water management and a schematic diagram of the life cycle have been set up which make it possible:

- to assess the supervision of formation, collection and utilization of oily and engine bilge water;
- to effectively control energy and stock quantities supplied to each stage of a technological process;
- to identify and assess the sources of the environmental pollution (ambient air, water, waste);
- to foresee and evaluate the priority regions of optimization of engine bilge water management.

Having made the environmental assessment, it was suggested to convert the waste resulting from the engine bilge water treatment into the energy and to use it in a technological process when closing (finishing) the life-cycle.

Key words: *oil waste, bilge water, oily water treatment, Klaipėda sea port, port waste, flux of waste, life-cycle, environmental assessment, pollution prevention.*

1. Introduction

The EU politics is to seek reduction in pollution, thus it encourages the international convention and search for common compromises among the Member States. This politics is based on a precaution principle and provision that the polluter compensates the damages and that application of preventive measures and pollution control are to be guaranteed in the Member States. The Member States guarantee that the expenses of the port equipment intended for pumping the engine bilge water and other waste, their treatment and disposal should be covered by shipping taxes.

The sea and seashore pollution of the Member States is a great concern to communities. Engine bilge water, trash washed from overboard cause a great deal of current environmental problems. The EU politics strives to ensure the accomplishment of the International Convention (1973) for prevention of shipping waste, the latter being appended with the Marpol Protocol of 1978 (Marpol 73/78).

Lithuania is one of the countries that ratified the Marpol 73/78 Convention which deals with the measures and prevention of sea pollution with engine bilge and oily water and other substances. The European Parliament and Council Directive 2000/59/EB November, 27, 2000 is also applied whose aim is to reduce the amount of shipping waste washed overboard into the sea and to improve the availability and application of the port technological equipment, thereby increasing the environmental protection. This Directive is applied to the ports of all the Member States.

Klaipėda sea port is the most north-distant ice-free port in the Eastern Baltic Sea. It is the most important and biggest transport unit in the Republic of Lithuania connecting the sea, the overland and the railway from the east and the west. The port is capable of reloading up to 40 million tons of various cargoes and serves more than 8000 ships that, in one way or another, provide the conditions for accumulation of big amounts of different waste which the port manages to fix within the framework of the waste treatment plan.

In ports, including Klaipėda sea port, specific kind of waste is formed - so called engine bilge water. It is specific water, hazardous to the environment as it is a liquid compound of water and oil products acquiring special properties during its collection and treatment processes. The treatment processes of this type of waste require a variety of different equipment and technological processes, special control related to combustibility and inflammability in conformity to the International and EU Regulations on the waste treatment. For this reason, analysis of specific streams of waste treatment and enhancement of effectiveness of environmental protection are of great importance.

This research aims at developing the life-cycle of oily and engine bilge water treatment and management in the port and at assessing its environmental protection.

Tasks of this research are the following:

1) analysis of engine bilge and oily water, technological processes and documents flow;

2) development of life cycle of the pumped polluted engine bilge water in Klaipėda port.

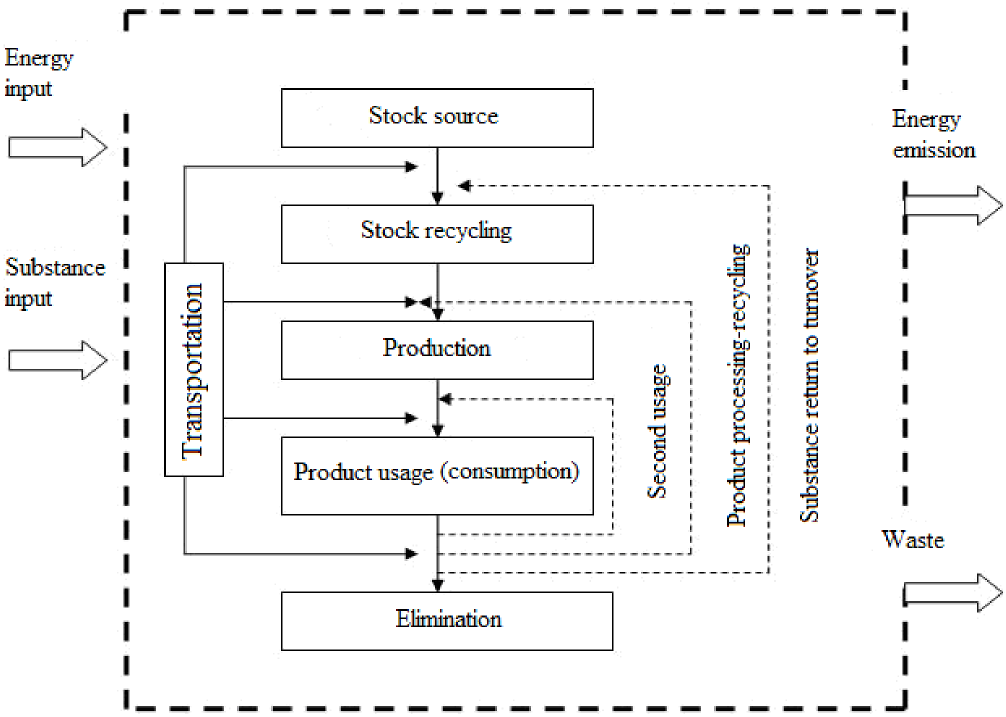

Fig. 1. Schematic diagram of life- cycle assessment (Staniskis J.K., 2005)

2. Application of the environmental protection effectiveness and pollution identification methods

2.1. Life-cycle assessment (LCA)

An impact of a product, service, and technological process on the environment has to be analyzed from its beginning to its end including all common interaction with the environment. Life cycle includes such components as stock preparation, energy generation, transportation, production, packing, distribution, technological processes, consumption, waste management and utilization. A life cycle approach requires that reduction of an impact on the environment in one stage would not increase it in another stage (Staniskis J.K., 2005). This procedure set is intended for both collection of the data about all substances and energy input and waste that may be directly attributed to product functioning during its all life cycle, and assessment of the entire impact on the environment. A schematic diagram of the life cycle is presented in Figure 1.

LCA is assessment of water and energy input, chemically-polluted sludge, transport pollution while transporting stock and products, fluxes of waste. Therefore, while assessing services, technological processes or products, attempts have been made to analyze the impact on the environment it might have during both production stages and exploitation and product recycling (*Staniskis J.K., 2005*).

LCA invokes the ISO 14040 standards prepared by the *International Organization of Standardization*. According to the ISO 14040 series standards (14040, 41, 42, 43, and 48), LCA is divided into four parts:

1) *definition of task and application sphere* that explicitly states the aims and limits of the analysis;
2) *inventory analysis* that keeps to the estimation and quantity calculation of energy, stock and emissions to the air, water and soil;
3) *during the life cycle impact assessment* inventory results about an impact on the human health, the environment, natural resources extinction, etc. are recalculated;
4) possibilities of reducing an impact on the environment are estimated *during the interpretation.*

These components may be used all together or separately and their sequence is of no importance (Staniskis J.K., 2005).

3. Research results

3.1. Waste amount and its management in Klaipėda port

According to the information given by Klaipėda state sea port Directorate (hereinafter KSSPD), the Port Maintenance Department presented the flows of ships (Table 1) according to the entering ships type and their number (*VĮ KVJUD, 2003*; *Klaipėdos valstybinio* ...2007).

Table 1. The number of ships entering Klaipėda port in 2008

Type of ships	The number of entrances
Tankers	543
Passenger ships and ferries	901
Barges, fishing ships, dredgers	3936
Dry cargo ships	2913
Entertainment boats	No data
Total	8348

Table 2 presents the analysis data on the quantities of reloaded cargoes and container flows in Klaipėda port in 2007-2008.

Table 3 presents information on waste types and amounts in 2008 according to the data from KSSPD (*VĮ KVJUD, 2003*; *Klaipėdos valstybinio*...2007).

Table 2. Reloaded cargo quantities in Klaipėda Port in 2007-2008

Cargoes (thousands of tons)	Reloaded	
	2007	2008
Liquid cargoes	8875,05	10375,04
Bulk cargoes	7797,31	9377,96
General cargoes	8428,96	10028,26
Total (thousands of tons)	25846,20	29880,00
Ro-ro cargoes (units)	225662	256126
Ships	7800	8450
Containers (TEU)	373263	423653
Passengers	285216	323720
Butinge Terminal	6115,46	6941,05

Table 3. Collected waste types and amounts in Klaipėda port in 2008

Type of waste	m³	Percentage of the whole amount of waste
Oily waste	10609	73.73%
Harmful liquid waste	0	0%
Drudge	218	1.52%
Trash	3853	26.78%
Oily rags	127	0.88%
Total:	14 389	100%

The waste formation analysis has indicated that majority of waste in Klaipėda port is composed of oil waste. This fact points to the relevancy of the subject (VĮ KVJUD, 2003; Klaipėdos valstybinio...2007; Aplinkos būklė, 2008). Having done the analysis of technological processes of oily water management and documents flow, the waste treatment output has been estimated. Location of the main loading companies and waste supply equipment is given in Figure 2.

”Klaipėdos keleiviu ir kroviniu terminalas” Ltd which has primary treatment equipment performs the operator's functions of waste pumping overboard in Klaipėda port. Companies "Klaipedos Nafta" Ltd and "Kroviniu terminalas" Ltd also have oily water treatment equipment (VĮ KVJUD, 2003; Klaipėdos valstybinio...2007; Aplinkos būklė, 2008).

3.2. Documents flow analysis Oil waste management in Klaipėda port

According to the Marpol 73/78 requirements for the fluxes of waste, the following waste management procedures are designated (VĮ KVJUD, 2003; Klaipėdos valstybinio...2007; Aplinkos būklė, 2008):

1) reports given before the ship's entrance;
2) orders to collect waste on board of a ship;
3) collection of oil waste;
4) document given to Ship's Captain on waste collection and delivery;
5) oil waste utilization.

Chart 2 indicates the management of information and documents flow in Klaipėda port. The port documents flow consists of two sub-systems:

1) on waste collection and document handing to Ship Captain (documents flows);
2) on KSSPD requirements to perform waste collection safely, skillfully, without causing risk to the other port proceedings systems and keeping to safety, climate and other requirements.

3.3. Work flows of the management of oily water and waste

Oil waste collection is performed according to the Marpol 73/78 Appendix 1 *(Tarybos direktyva 2000/59/EB; MARPOL CONSOLIDATED EDITION 2006).* According to the documentation the port dispatcher organizes oil waste collection from ships when they enter Klaipėda port. A part of ships that have on board some ballast water (*Hussein, M., et. al. 2008*; *Racys V., et. al. 2005*) deliver it directly to oil loading companies. The other part of ships that contain engine bilge water must deliver it according to valid documents to the waste management operator. The operator collects the waste into special-purpose ships – bunkers that have the suitable equipment and skilled personnel for collecting oil-polluted water (*Mažeikienė A., et. al., 2005*; *Fernandes, R.S., et. al., 2004*). These ships work 24 hours a day. Engine bilge water, spilled oil products or cargo remnants are delivered by an operator to the operating and maintained primary oil polluted water treatment equipment. Waste generated during no-good transportation of liquid hazardous substances is collected under the requirements of the. Marpol Appendix 2. Port dispatcher organizes collection of domestic waste and hazardous/harmful waste (i.e. oily rags). Trash is collected by means of specific ships or specific transport keeping to the Marpol Appendix 5 requirements. Companies that collect and utilize waste and cargo remnants according to the valid documents record have to hand the monthly reports to KSSPD up to the 10th of the next month to (*VĮ KVJUD, 2003*; *MARPOL CONSOLIDATED EDITION, 2006*).

Oily waste utilization according to Marpol Appendix 1 (*VĮ KVJUD, 2003*; *MARPOL CONSOLIDATED EDITION, 2006*) is done by the loading companies that load ships and in a case of this type of waste they take all responsibilities for proper utilization of this type of waste, keeping to all international agreements and port work regulations. Polluted water of the other type – engine bilge water (*Haussard, M., et. al., 2003*) has to be delivered to the operator's water treatment equipment on the shore. The main specific property of engine bilge water is its indeterminate volatile composition. It contains various hydrocarbons (benzene, toluene, xylene compounds, and polycyclic aromatic hydrocarbons – PAH, naphthalene, methyl-phenol, and phenol), fuel, lubricants, oil, light benzene fractions (*Malikov, I.N., et. al., 2007*; *Deschamps, G., et. al., 2003*). Cargo remnants have to be utilized according to conventions/contracts between the ship and the loading company. The operator has to satisfy all qualifying and technical requirements. Delivered waste is sorted out. Oily rags as well as quarantine waste are collected into special separate tanks and taken away for incineration. Companies that collect and utilize cargo remnants present monthly reports to

KSSPD up to the 10th of the next month. When leaving the ports, the ships must leave their waste and cargo remnants there.

As Helsinki Council recommends sanitary charge is collected in Klaipėda port (*Klaipėdos valstybinio*...2007; *Tarybos direktyva 2000/59/EB*; *Marpol, Consolidated Edition, 2006*). Due to it, some waste from ships is taken free. However, ballast, engine bilge, washing, chemically-pollutes water, paint residues are pumped bargaining with port companies though such a service has to be given for free. Therefore, the risk remains that ship crews may get rid of polluted water illegally. (*Stakėnienė, R., 2003*; *Spruogis, A., Jaskelevičius, B., 2000*; *Racys V., et. al. 2005*). General waste flow and oil waste utilization principles are given below in Chart 1.

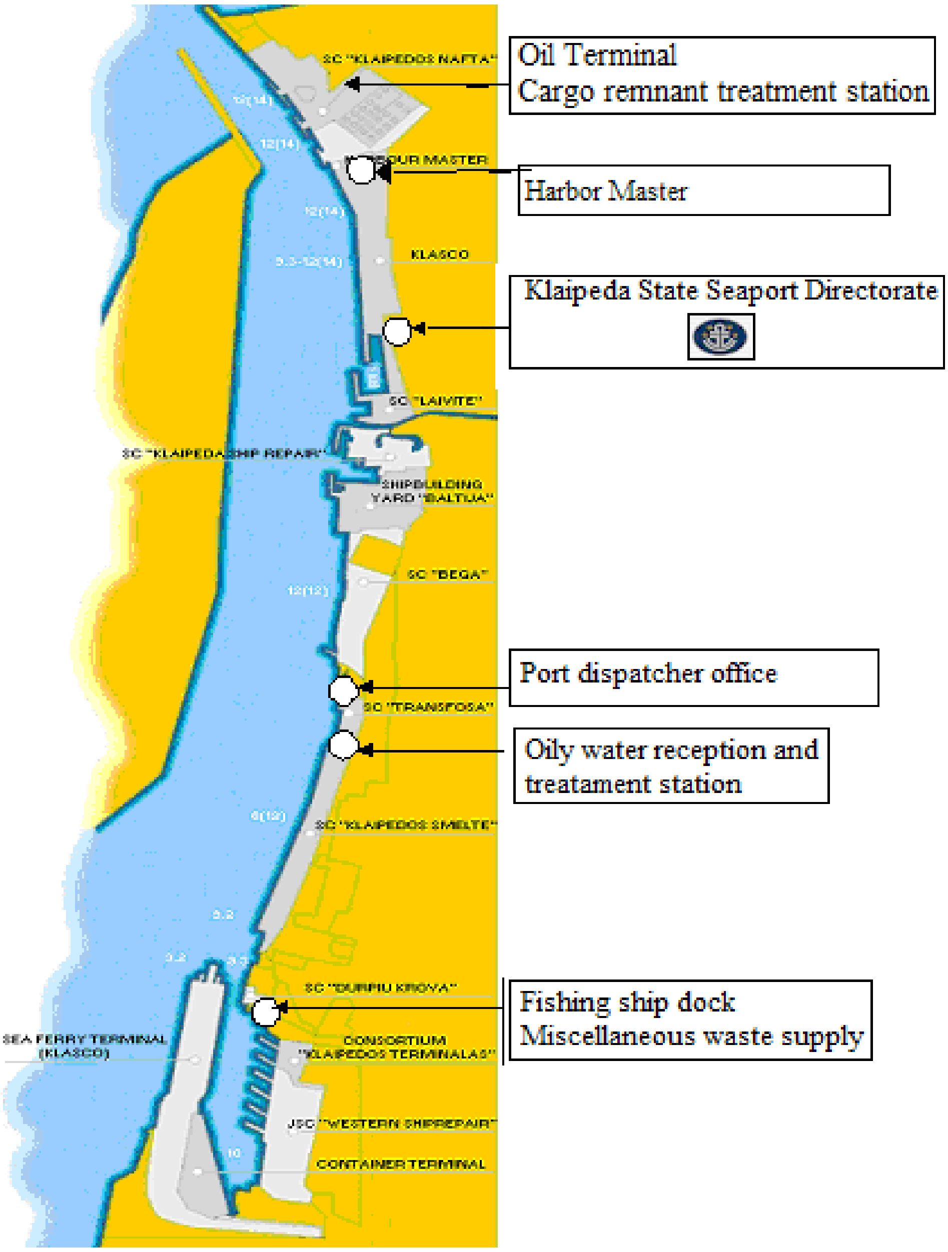

Fig. 2. Location of the main loading companies and waste supply stations (Klaipėdos valstybinio...2007)

3.4. Ship waste collection and its management in Klaipėda port

While following both "Pollution from ships prevention regulations" Marpol 73/78 (*Tarybos direktyva 2000/59/EB*; *Marpol, Consolidated Edition, 2006*; *DANCEE, 2002*) that describe measures for reduction and prevention of sea pollution with oil products from ships and the regulations by the European Parliament and Council Directive 2000/59EB (*Tarybos direktyva 2000/59/EB*), Klaipėda port seeks to reduce discharge of ship and cargo waste into the sea and the environment.

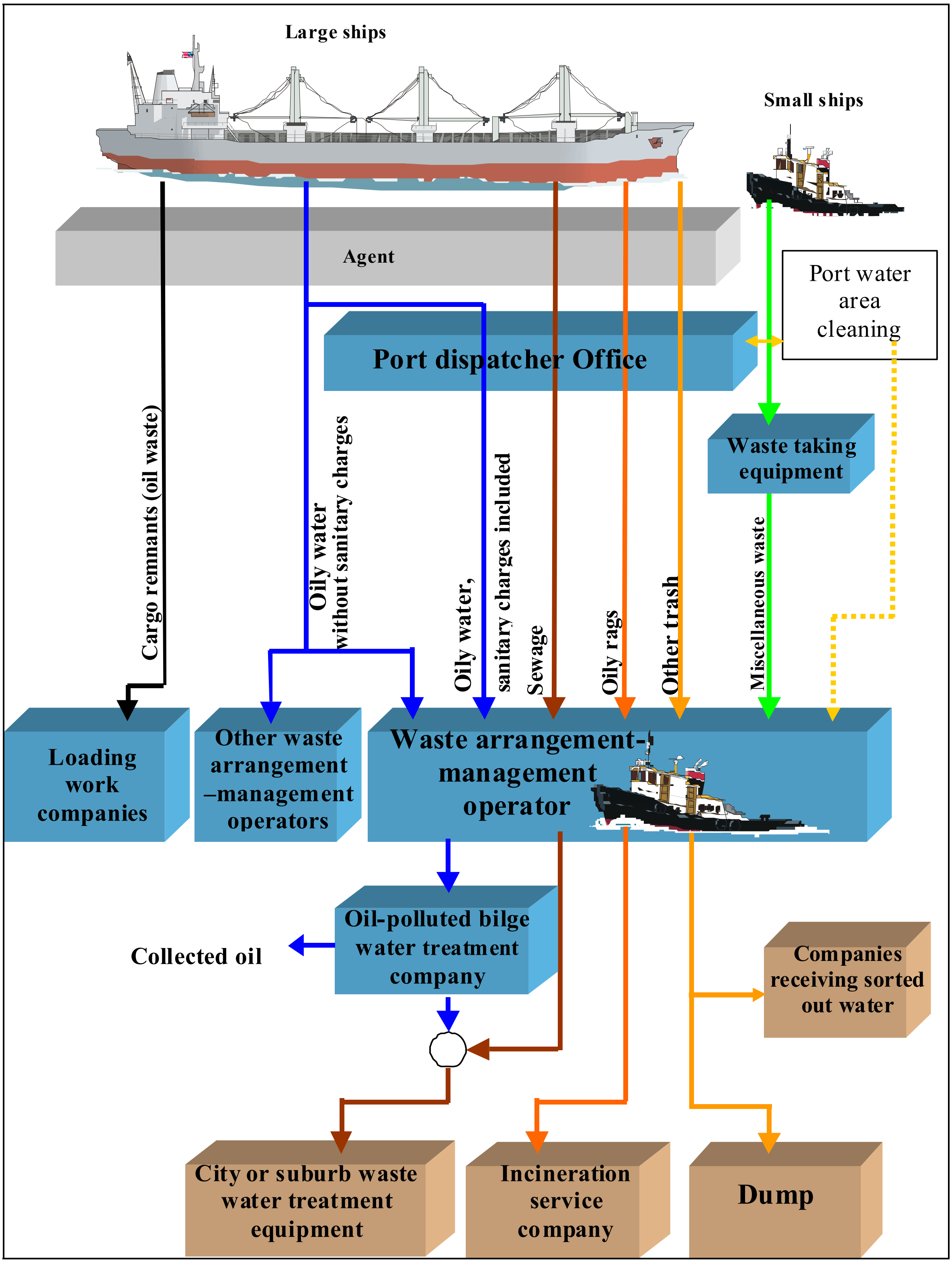

Chart 1. *Flux of waste and utilization in Klaipėda port (Klaipėdos valstybinio...2007)*

In Klaipėda Port about 10 000 m³ of oily water was collected in 2008. Applying life-cycle assessment methods (Staniskis J.K., 2005), the scope of research has been determined and research sphere has been defined that include all flows of oily and engine bilge water in Klaipėda port.

Having finished a full inventory analysis of oily water, the amount of stock and energy resources used in processes, emissions to the air, water and other natural components have been estimated. According to the life-cycle assessment algorithm, equipment and technological processes of oily sludge treatment have been designed with a potential for identifying, correcting, selecting or complementing various processes in the complete life cycle of port oily water management (Staniskis J.K., 2005; Klaipėdos valstybinio...2007; CONCA WE's, 2004).

After the analysis of the life cycle of oily and engine bilge water management in Klaipėda port, the following problems requiring for a more exhaustive analysis and for a more reliable model of fluxes of waste management and control have been stated:

1) oily and engine bilge water collection from ships and document flows control;
2) collection of spilled oil products keeping to all safe exploitation requirements;
3) exploitation of medium accumulative tanks in the port;
4) regular transportation of accumulated oily and engine bilge water to the oil-polluted water treatment station
5) distribution, storage, treatment (mechanical, physical, sorption) of delivered oily and engine bilge water.

LCA of oily and engine bilge water management in the port includes the data of inventory analysis of waste management in technological processes, inventory analysis of document control process stages, impacts assessment and chart-development, and possible improvement of reduction of an impact on the environment

Chart 3 presents a lay-out of the life cycle of the oily and engine bilge water management in the port. Identified technological processes of the engine bilge water management and the data of comparative analysis are given in Table 4. Table 4 also explains separate points of Chart 3.

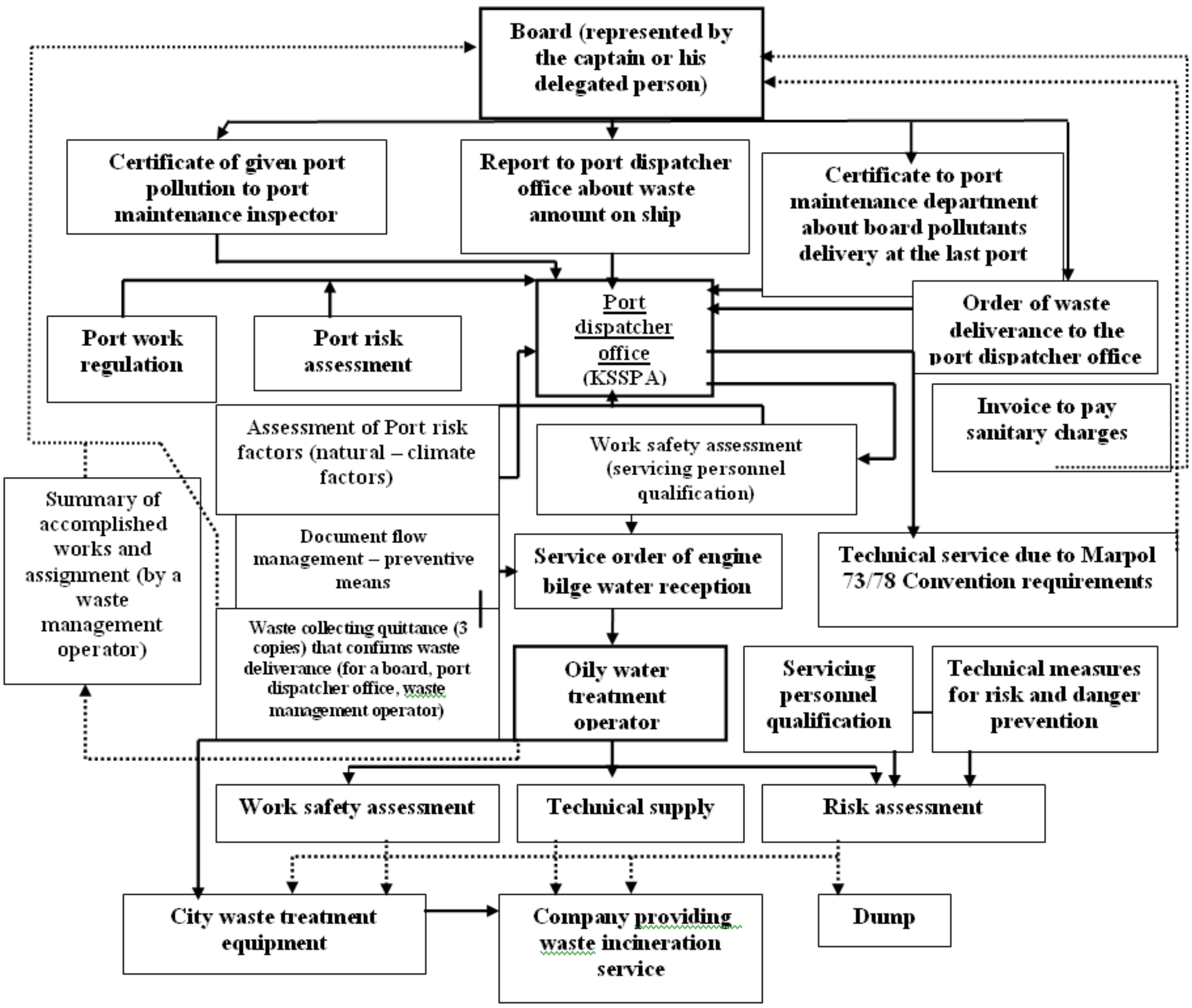

Chart 2. Information and document flow control in Klaipėda port

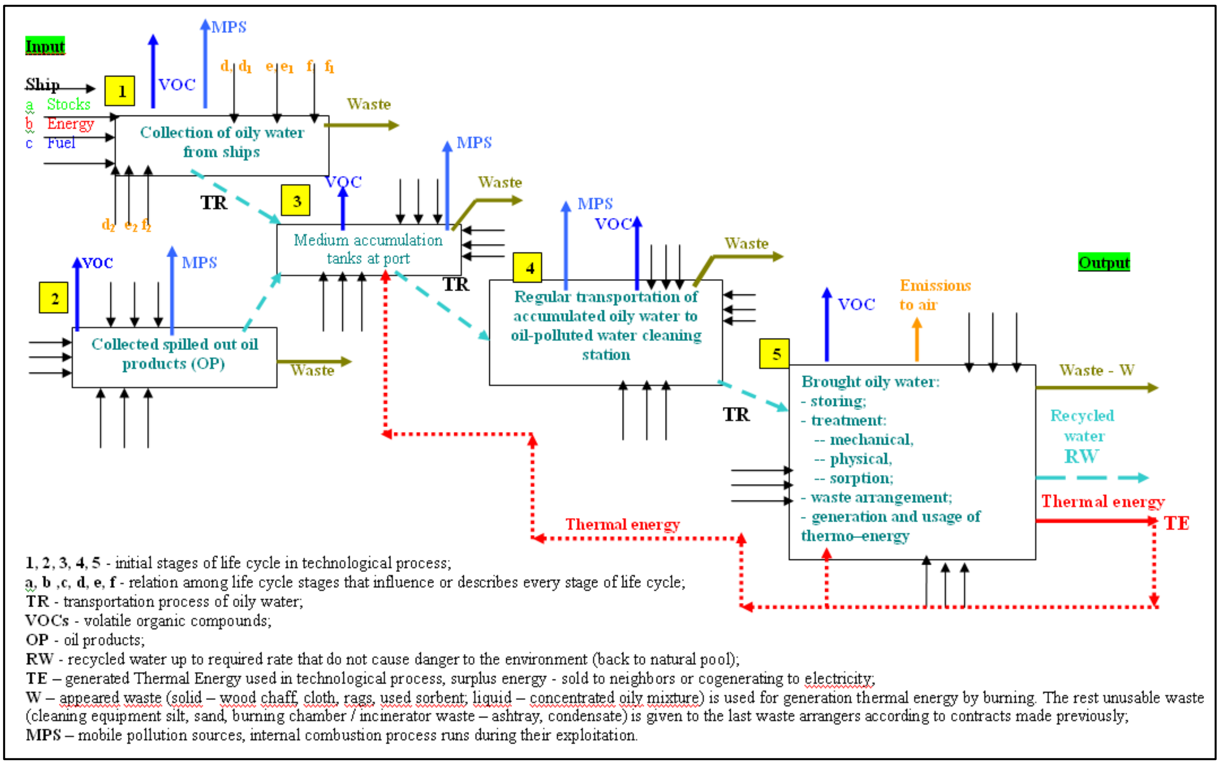

Chart 3. Schematic diagram of life cycle of collection, treatment, distribution and utilization of water polluted with engine bilge, oil and its products

4. Discussion on work results

After the analysis of utilization of fluxes of oil waste and oil-polluted water and documents on these processes, it has been determined that some of them do not have any feedback and some of them get to the dump and are burned. In this way, the Marpol 73/78 Convention requirement for reducing sea pollution with oil products is not followed and the environment continue to be polluted (Tarybos direktyva 2000/59/EB; Marpol, 2006; Smailys,V., Tilickis, B., 2001).

The complete analysis of the documents flow has indicated (Chart 2) that only a part of documents reflect essential environmental status in the port while they are not integrated into the common management system. The positions as risk operation, personnel qualification, and technical supply are neither integrated into the technological process nor into the document delivery flow.

The inventory analysis reveals an urgent need to reduce an impact on the environment during the unloading of hazardous engine bilge and other oil water, to estimate the possible impact caused by technological processes, reloading, transportation, climate conditions (icing, wind, temperature, etc) and to assess which factors affect each technological process (Staniskis J.K., 2005; Technical Proceedings, 2006; Arundel J., 2000).

By applying a systematic approach to the oil waste management in the port, an algorithm based on life cycle has been set up (Chart 3). The system of waste management in the port is a set of technological processes each of which performing a certain function and demanding stock, electric energy, fuel, transport, heat, technological equipment, etc.

In addition, certain limits can be drawn to each technological component that would include all interrelated and prevailing processes. As you can see from Chart 3, every process requires some stock, electric energy, fuel, transport, heat, technological equipment, etc.

To estimate the environmental effectiveness of specific waste management, every stage of a technological process is analyzed by applying the life cycle methodology (Staniskis J.K., 2005), thereby assessing the material resources necessary for the waste management, the external factors influencing both safety and quality of the processes and the additional technological processes such as transportation, management and preventive measures.

The methods of life cycle assessment foresee the possibility to estimate the environmental effectiveness by calculating the input and planning the potential of its reduction. Inventory practical data show that engine bilge water may make up to 10 000mg/l oil product concentration (VĮ KVJUD, 2003; Arundel J., 2000; Gerasimov, G.N.; 2006; Krylov, I.O., 2008). It has been calculated assuming that an average engine bilge water concentration – 5000mg/l is introduced into the modeled life cycle assessment algorithm. Calculation has been done integrating input and output of energy and substances, additional substances, etc. Conditional impacts on the environment, assuming 10 000 m^3 amount of engine bilge water, are calculated and presented in Table 4.

According to the methods, the environmental impact has been evaluated and calculated during assessment of a life cycle (Table 4). It indicates that energy–material resources are mostly used at stage 5 of life cycle and exceed electricity and heat expenditure four times compared to all stages of life cycle. However, the external factors affect this process less. Material expenditures for additional processes have an indistinct influence on life cycle. The analyzed substances do not depend on the stage sequence of their application or generation. Therefore, according to the analysis, essential changes the environmental impact is to be reduced at the stages of engine bilge water distribution, storage and treatment. Having assessed the possibility to decrease an actual impact on the environment, it is noticed that during the process of engine bilge water collection, transportation and treatment about 1 500 t/m of concentrated oil product mud (equated to fuel oil) and about 350 t/m of solid oil-polluted waste are generated. In total, in a year about 1850 t/m of solid oil-polluted waste feasible to be burned up is formed that may by the source of generating thermal energy. The quantity of energy generated in this way would amount to 5 000 Gcal or 5 800 MWh.

The calculations done in this research make it possible to suggest the improvement in the life cycle schematic diagram (Chart 3, a red dotted line). According to this improvement, the burnt oil waste is used for generating thermal energy that is applied to technological processes thereby closing the life cycle and reducing an impact on the environment by 60 % because the generated energy may fully cover the engine bilge water treatment process. A part of generated energy is left for co-generation or market, thus heat should not be acquired from other heat suppliers. Surplus heat having been directed to the co-generation power station or the market, it can be either sold or applied to technological processes.

Following the Directive of the European Parliament and Council 2000/59/EB, 2000 and seeking to improve availability and application of port waste reception – management and other technological equipment at Klaipėda Port (Marpol, 2006; Atliekų tvarkymo taisyklės, 2004) oily waste originating during various waste management processes is suggested to be converted into energy and to be used by directing it back to technological processes and in this way to reduce expenses of current services and to improve environmental effectiveness.

In this life cycle analysis the calculations have indicated that an impact on the environment declines and efficiency of the processes increases by about 20 % with respect to the generated and used thermal energy. Chart 3 presents a set up scheme of life cycle of engine bilge water management in Klaipėda port which suggests to use the waste resulting from the processes of oil polluted water treatment fto generate thermal energy and to direct it back to technological process.

Table 4. Life cycle analysis of oil water management

Stage of life cycle	Title	Comparative analysis of technological process of oil water management					
		a, b, c - material resources for a technological process of OW and BW management in the port		**d, e, f** – outer factors influencing a technological process of OW and BW management in the port	**d_1, e_1, f_1** – additional processes for OW and BW management technology in the port	**d_2, e_2, f_2** – assessed impacts on the environment	
1	Oily and engine bilge water delivered from ships	Fuel	10 t/m	Qualification of servicing personnel when collecting oily and engine bilge water	Transportation	VOC vapouring	0.02 t/m
		Other substances					
		Sorbents	0.1 t/m	Natural – climate factors causing risk (icing, wind, temperature, waving, etc)	Cargo distribution	Mobile pollution sources (MPS)	CO - 0.2 t/m
		Surface active substance s (SAS)	0.05 t/m				NO_x - 0.54 t/m
							CH - 0.144 t/m
							SO_2 - 0.01 t/m
					Technical measures for preventing risk and danger		kd - 0.05 t/m
					Estimate concentration and composition of oil products when choosing OW and EBW receiver	Waste	0.36 t/m

Stage of life cycle	Title	Comparative analysis of technological process of oil water management					
		a, b, c - material resources for a technological process of OW and BW management in the port		**d, e, f** – outer factors influencing a technological process of OW and BW management in the port	**d_1, e_1, f_1** – additional processes for OW and BW management technology in the port	**d_2, e_2, f_2** – assessed impacts on the environment	
2	Collection of spilled oil water	Fuel	15 t/m	Supply of equipment for oil products collection and utilization (skimmers, pumps, etc)	Managing – preventive measures of document flows	VOC vapouring	0.02 t/m
					Transport to the receiving point	MPS	CO - 0.2 t/m
		Other substances					NO_x - 0.54 t/m
		Sorbents i	0.2 t/m	Qualification of servicing personnel			CH - 0.144 t/m
							SO_2- 0.01 t/m
							kd - 0.05 t/m
						Waste	0.54 t/m
3	Exploitation of medium accumulative tanks in the port	Electricity	3.2 MWh	Natural – climate factors causing risk (icing, wind, temperature, waving, etc)	Estimation of concentration and composition of OW and EBW when choosing the technological treatment line	VOC vapouring	0.270 t/m
		Thermal energy	107 MWh			Waste	0.35 t/m
4	Regular transport of accumulated oil water to oil-polluted water treatment station	Fuel - 1.42 t/m		Qualification of servicing personnel	Managing– preventive measures of document flows		CO - 0.1 t/m
							NO_x - 0.25 t/m
							CH - 0.08 t/m
							SO_2- 0.005 t/m
					Transport		kd - 0.025 t/m
5	Distribution, storage, treatment (mechanical, physical, sorption) of delivered engine bilge water, Waste management when closing the cycle by applying thermal energy	Electricity	12.8 MWh	Technical state of oil products treatment equipment	Managing – preventive measures of document flows	VOC vapouring	0.450 t/m
		Thermal energy	426 MWh	Hazardous waste		Emission to the air	CO - 4.0 t/m
		Water	500 m^3/m	Qualification of servicing personnel			NO_x - 1.5 t/m
		Other substances			Prevention and reduction of risk and danger		SO_2- 1.5 t/m
		Flocculants / coagulants	0.15 t/m				kd - 0.015 t/m
		Sorbents	0.15 t/m		Estimation of Oil product concentration and coposition in treated output water	Waste	2.16 t/m

Explanations of Table 4 terms: *1. Analysis of life cycle performed with 1000 m³ of engine bilge water; 2. SAS - surface active substances; 3. MPS - mobile pollution sources; 4. EBW - engine bilge water; 5. OW – oily water.*

5. Conclusions

This research has made it possible to draw the following conclusions:

1) After a thorough analysis of both the engine bilge water formed on board or in other technological processes and the document flows, drawbacks in processes and document flow management have been estimated.
2) A control assessment algorithm of technological processes of engine bilge water management and document flows and schematic diagram of life cycle allow:
   – to assess the control of waste composition, collection and utilization;
   – to effectively manage stock and energy amounts for each stage of a technological process;
   – to identify and evaluate the sources of environmental pollution (ambient air, water, waste);
   – to foresee the priority spheres of waste management optimization.

Having done the environmental assessment, generated waste is suggested to be converted into energy and to be applied to a technological process thereby closing life cycle.

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Klaipėdos uosto užterštų naftuotų vandenų tvarkymo analizė

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Lietuva yra viena iš šalių, ratifikavusių Marpol 73/78 konvenciją, kurioje numatytos jūros taršos iš laivų naftos produktais ir kitomis medžiagomis sumažinimo ir prevencijos priemonės. Uostuose taip pat taikoma Europos Parlamento ir Tarybos direktyva 2000/59/EB dėl laivuose susidarančių atliekų ir laivų krovinių likučių išmetimo į jūrą mažinimo.

Atlikus Klaipėdos uoste įplaukiančių laivų analizę nustatyta, kad naftuotos atliekos sudaro apie 74 % visų surenkamų atliekų kiekio. Išanalizavus technologinius srautus ir dokumentus atsiranda problemų šiuose procesuose: 1) naftuotų ir lijalinių vandenų surinkimo iš laivų; 2) išsiliejusių naftos produktų surinkimo; 3) tarpinių akumuliacinių talpyklų uoste eksploatavimo; 4) reguliaraus susikaupusių naftuotų ir lijalinių vandenų transportavimo į nafta užterštų vandenų valymo bazę; 5) atvežtų lijalinių vandenų paskirstymo, saugojimo, valymo (mechaninis, fizikinis, sorbcinis).

Uostuose tarp nafta užterštų atliekų susidaro specifinė atliekų rūšis – naftuoti vandenys, kurie atliekų tvarkymo taisyklėse įvardyti kaip „lijaliniai vandenys". Lijaliniai vandenys ypatingi ir pavojingi aplinkai dėl to, kad tai yra skystas, pavojingas aplinkai įvairių naftos produktų ir vandens junginys, gebantis sudaryti patvarias emulsijas, turintis ypatingas specifines savybes įvairių technologinių procesų metu. Šios specifinės atliekos tvarkymo procesams reikalingi įvairūs įrenginiai, technologiniai procesai, valdymo specifika, susijusi su degumu ir sprogumu, taip pat atitiktis tarptautiniams ir ES teisės, technologinių procesų valdymo ir dokumentų reikalavimams. Todėl svarbu išskirti šią specifinę naftuotų vandenų rūšį iš bendro nafta užterštų atliekų konteksto ir atlikti šių atliekų tvarkymo srautų analizę, siekiant padidinti aplinkos apsaugos veiksmingumą šios naftuotos atliekos tvarkymo procesų metu.

Taikant sisteminį požiūrį į naftuotų atliekų tvarkymą uoste, sudarytas atliekų tvarkymo sistemos algoritmas, kuris paremtas būvio ciklu. Uosto atliekų tvarkymo sistema – tai technologinių procesų rinkinys, kurių kiekvienas atlieka tam tikrą funkciją, taip pat reikalauja žaliavų, elektros energijos, kuro, transporto, šilumos, technologinių įrenginių ir kt.

Atlikus tyrimus, sudarytas lijalinių vandenų tvarkymo technologinių procesų ir dokumentų srautų kontrolės vertinimo algoritmas ir principinė būvio ciklo schema, kuri leidžia:

- įvertinti naftuotų ir lijalinių vandenų susidarymo, surinkimo ir utilizavimo kontrolę;
- efektyviai valdyti kiekvienam technologinio proceso etapui tenkančius energijos ir žaliavų kiekius;
- identifikuoti ir įvertinti aplinkos taršos šaltinius (aplinkos oras, vanduo, atliekos);
- numatyti lijalinių vandenų tvarkymo valdymo optimizavimo prioritetines sritis.

Atlikus aplinkosauginį vertinimą, pasiūlytas lijalinių vandenų tvarkymo metu susidarančias atliekas paversti energija ir ją panaudoti technologiniame procese uždarant (užbaigiant) būvio ciklą.

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