UDK: 628.394:629.541

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METODE TRETMANA OTPADNIH VODA SA BRODOVA

METHODS OF TREATMENT WASTEWATERS FROM SHIPS

APSTRAKT

Postoji nekoliko kategorija otpadnih voda sa brodova. Najvažnije od njih su: kaljužna, balastna, siva i crna (sanitarna) voda. Upravljanje otpadnim vodama brodova i njihov tretman se sastoji od složenog sistema koji uključuje niz metoda sakupljanja i obrade, upravo zbog različitog porekla i sastava ovih voda Predmet istraživanja u ovom radu je razmatranje mogućnosti savremenih tretmana otpadnih voda sa brodova i njihova sistematizacija u skladu sa zakonskim propisima.

Ključne reči: balastna voda, brodovi, kaljužna voda, sanitarna voda, tretmani vode.

ABSTRACT

There are several categories of wastewater from ships. The most important of them are: bilge, ballast, grey and black (sanitary). Ship's waste water management and their treatment consists of a complex system that includes a range of collection and treatment methods, precisely because of the different origin and composition of these waters. The subject of research in this paper is options consideration of modern treatments for waste waters from ships and their systematization in accordance with the legislation regulating.

Key words: ballast water, bilge water, sanitary water, ships, water treatments.

UVOD

Postoje tri glavne kategorije otpadnih voda koje proizvode brodovi: kaljužne (zauljene), sanitarne (crne i sive) i balastne voda. Sanitarne vode su otpadne vode nastale mešanjem sive i crne otpadne vode (kanalizacija). Velika količina sanitarnih otpadnih voda nastaju na putničkim brodovima i velikim krstaricama zbog izuzetno velikog broja ljudi na brodu. Kaljužne vode sa brodova su zauljene vode koje nastaju u različitim mašinskim prostorima, kao i otpadne vode iz brodskog skladišta, proizvedene od odlaganja ostataka tereta i atmosferskih padavina.

ZAKONODAVSTVO KOJE SE ODNOSI NA OTPADNE VODE SA BRODOVA

Brojne međunarodne rezolucije i konvencije bave se pitanjima zaštite životne sredine u plovidbi, kao što su: Rezolucija 61, UNECE, Rezolucija 24, CEVNI, UNECE, Međunarodna konvencija o ADN - Evropske odredbe o međunarodnom prevozu opasne robe unutrašnjostim vodnmi putevima (UNECE 2015), kao i Konvencija o plovidbi brodovima unutrašnje plovidbe, 1966. Takođe, Dunavska komisija je proizvela smernice za upravljanje otpadom i otpadnim vodama

INTRODUCTION

There are three main categories of wastewater produced by ships: bilge (oily), sanitary (black and gray) and ballast water. Sanitary water is waste water formed by mixing gray and black waste water (sewage). A large amount of sanitary waste water is generated on passenger ships and large cruisers due to the extremely large number of people on board. Bilge water on ships is oily water produced by different machine spaces, and also wastewater from the ship warehouse, produced from the disposal of cargo residues and atmospheric precipitation.

LEGISLATION RELATED TO WASTEWATER FROM SHIPS

Numerous international resolutions and conventions address the issues of environmental protection in navigation, such as: Resolution 61, UNECE, Resolution 24, CEVNI, UNECE, International Convention on ADN - European Provisions on the International Carriage of Dangerous Goods in Inland Waterways (UNECE 2015), as the Convention on calibering inland navigation vessels, 1966. Also, the Danube Commission has produced guidelines for waste and waste water management with ships on the Danube (Danube Commission 2013). There

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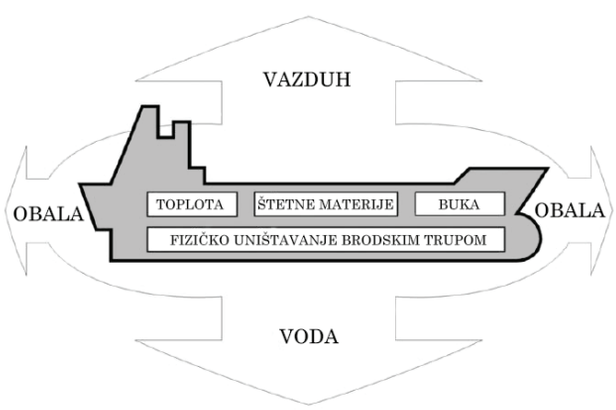
sa brodova na Dunavu (Dunavska komisija 2013). Tu su i osnovne odredbe o plovidbi Dunavom, Direktiva 87/2006 (EC-Brisel), Minimalni tehnički zahtevi za plovila unutrašnje plovidbe. U Republici Srbiji, prvi Pravilnik koji je započeo proces pravnog regulisanja otpadnih voda sa brodova, definiše vrste otpadnih voda (sve gore pomenute, osim balastnih voda), ali ne razmatra detaljno metode njihovog tretmana (Pravilnik 2017).

Najvažnije kategorije otpada sa brodova za koje je regulisano odlaganje su ostaci ulja i taloga nastalih uslded rada motora (Aneks I) i komunalni otpad (Aneks V) i otpadne vode (Aneks IV). Aneks V (komunalni otpad) i Aneks IV (otpadne vode) funkcija su broja putnika posade iobuhvataju komunalni otpad, čvrsti otpad u velikim pakovanjima i ostatke brodskog tereta, plastiku, otpad za održavanje kao što su čađ, , strugotine i dr. ostaci od boja. Prilog I odnosi se uglavnom na talog i ostatke nastale usled rada motora i kaljužne vode (MARPOL 73/78). Količina ove vrste otpada sa brodova varira u zavisnosti od kapaciteta motora, vrste ulja i kvaliteta motora. I mulj i kaljužnu vodu treba ispumpavati. (Beza 2014).

MOGUĆE OPASNOSTI PO ŽIVOTNU SREDINU OD BRODOVA

Moguće opasnosti po životnu sredinu od brodova spadaju u sledeće kategorije: fizičke, termičke, hemijske i biološke (EPA 2017). Na slici 1. shematski su prikazani štetni uticaji brodova na životnu sredinu (Jelavić 2007).



Slika 1. Shematski prikaz štetnih uticaja brodova na životnu sredinu

Takođe, kaljužne vode sadrže veliku količinu nečistoća kao i toksične, korozivne, zapaljive / eksplozivne karakteristike. Netretirane zauljene kaljužne vode koje se ispuštaju direktno u vodna tela mogu oštetiti vodeni ekosistem i brojne linije krstarenja su optužene za kršenje životne sredine u ovom pogledu (Olorunfemi 2015).

are also Basic Provisions on Danube Navigation, Directive 87/2006 (EC-Brussels), Minimum technical requirements for inland navigation vessels. In the Republic of Serbia, the first Rulebook which started the process of legal regulation of waste water management was recently adopted, defines the kind of waste waters (all the above mentioned except the ballast water), but there are not considered in detail methods of their treatment (Rulebook 2017).

The most important categories of ships waste for which the disposal is regulated are oil and other engine residues (Annex I) and household waste (Annex V), sewage and waste water (Annex IV). Annex V (household) and Annex IV (sewage and waste water) waste is related to the size of the crew includes domestic waste, solid waste in large packaging and ship cargo residues plastic, domestic waste, maintenance waste such as soot, machinery deposits, scrapped paint. Annex I consists mainly of sludge and engine residue, and bilge water (MARPOL 73/78). The amount of the ship produces varies with the engine capacity, the type of oil used, and the quality of the engine. Both sludge and bilge water need to be pumped out. (Beza, 2014).

POSSIBLE ENVIRONMENTAL HAZARDS FROM SHIPS

Possible environmental hazards from ships fall into the following categories: physical, thermal, chemical and biological (EPA, 2017). Figure 1 schematically shows the harmful effects on the environment from the ships (Jelavi**ć, 2007**).

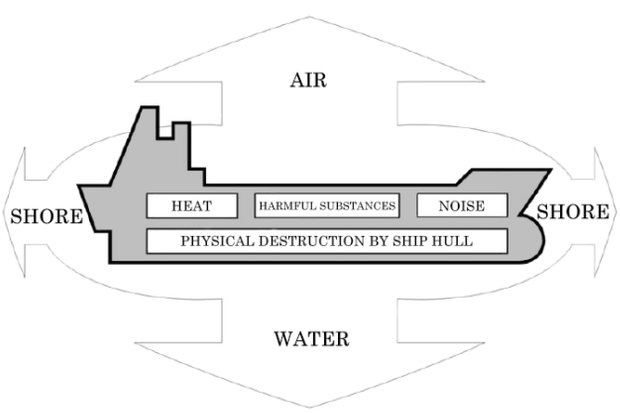


Figure 1. Schematic representation of harmful impacts from ships

Also, the bilge water includes a high amount of dirtiness as well as its toxic, corrosive, inflammable / explosive characteristics. Untreated oily bilge water discharged directly into the qater body can damage aquatic ecosystem and a number of cruise lines have been charged with environmental violations in this regard elsewhere (Olorunfemi et al., 2015).

TREATMAN KALJUŽNE VODE

Zauljena kaljužna voda je mešavina vode, ulja, maziva i masti, tečnosti za čišćenje i drugih otpadnih materija koje se akumuliraju u najnižem delu plovila iz različitih izvora, uključujući motore (i druge delove pogonskog sistema), cevovode i druge mehaničke i operativne izvore koji se nalaze unutar mašinskog prostora broda (EPA, 2008). Većina ovih otpadnih materija nastaje u prostoru za motore plovila i završava u kaljužnoj vodi. Vrste fluida procurele iz ovih izvora variraju, što dovodi do kompleksne smeše tečnosti u kaljuži plovila. Kaljužna voda može tipično sadržati različita goriva, maziva, antifriz, hidraulične fluide, rastvarače za **čišćenje i odmašćivanje, deterdžente, metal**e, katalitičke sitne čestice (čestice tvrdog aluminijuma i silicijum oksida koje su normalno prisutne u teškom loživom ulju), čađ i druge čvrste čestice (EPA, 2008). Sastav i fizičko-hemijske karakteristike kaljužne vode su veoma promenljive i menjaju se tokom vremena, kao i u zavisnosti od vrste plovila. Koncentracije ulja / ugljovodonika u kaljuži plovila obično su opsega 100 do 400 ppm. Pored ulja i ugljovodonika, kaljužna voda sadrži niz drugih zagađujućih materija. Ovo uključuje "klasične" zagađujuće materije (parametre potrošnje kiseonika, suspendovane **čestic**e), metale (arsen, bakar, kadmijum, hrom, olovo, živa, selen i cink) i organske (benzen, hloroform, heksahlorcikloheksan izomere, etil benzen, heptahlor, heptahlor epoksid, naftalin, fenole, estre ftalante kiseline, toluen, trihlorobenzen, trihloroetan, i ksilen) (EPA 1999). U nedavnom izveštaju EPA-e Kongresu o proučavanju ispuštanja komercijalnih ribolovnih plovila i drugih nerekreacijskih manjih plovila u normalnom radu (EPA 2010), izvršena je sveobuhvatna analiza ispuštanja kaljužnih voda iz malih komercijalnih plovila, uključujući ribarske brodove, brodove za vuču / spašavanje, vodene taksije i brodiće za krstarenja. Među metalima otkrivenim u kaljužnoj vodi, rastvoreni bakar, selen i cink, kao i ukupni arsen, dosledno su mereni u koncentracijama koje prelaze najstrože kriterijume kvaliteta vode iz nekoliko klasa plovila. Klasične zagađujuće materije BOD5, sulfidi, čestice (US**Č**) su pronađene u potencijalno značajnim koncentracijama u kaljužnoj vodi iz ribarskih brodova, brodova za vuču / spašavanje, vodenih taksija i brodića za krstarenja. Među nekoliko indikatora patogena, enterokok je bio prisutan u koncentracijama koje prelaze granične vrednosti kvaliteta u uzorcima kaljužne vode sakupljene sa ribarskih brodova. Ukupni fosfor je premašio referentnu vrednost za hranljive materije. Koncentracije poluisparljivih organskih jedinjenja (SVOC) bis (2-etiheksil) ftalata premašile su granične vrednosti u kaljužnim vodama ribarskih brodova, brodova za spašavanje, vodenih taksija i brodića za krstarenja. Benzen uzorkovan u kaljužnoj vodi iz brodova za vuču / spašavanje bio je jedino isparljivo organsko jedinjenje (VOC) koji je pronađen u koncentracijama koje prelaze najstrože granične vrednosti.

BILGE WATER TREATMENT

Oily bilgewater is the mixture of water, oily fluids, lubricants and grease, cleaning fluids and other wastes that accumulate in the lowest part of a vessel from a variety of sources including engines (and other parts of the propulsion system), piping, and other mechanical and operational sources found throughout the machinery spaces of a vessel (EPA, 2008). Most of these wastes are generated in the vessel's engine room and end up in the bilge. The types of fluids leaked from these sources varies, resulting in a complex mixture of fluids in the vessel's bilge. Bilgewater may typically contain various fuels, greases, antifreeze, hydraulic fluids, cleaning and degreasing solvents, detergents, metals, catalytic fines (cat fines are hard aluminium and silicon oxide particles that are normally present in heavy fuel oil), soot, and other solid particles (EPA, 2008). The composition and physical-chemical characteristics of bilgewater can vary widely, both over time and among vessels. Oil/hydrocarbon concentrations in vessel bilges commonly fall in the 100 to 400 ppm range. Aside from oil and hydrocarbons, bilgewater contains a variety of other pollutants. These include "classical" pollutants (oxygen-consuming parameters, suspended solids), metals (arsenic, copper, cadmium, chromium, lead, mercury, selenium and zinc) and organics (benzene, chloroform, hexachlorocyclohexane isomers, ethyl benzene, heptachlor, heptachlor epoxide, naphthalene, phenols, phthalate esters, toluene, trichlorobenzene, trichloroethane, and xylene) (EPA, 1999). In EPA's recent report to Congress on the Study of Discharges Incidental to Normal Operation of Commercial Fishing Vessels and Other Non Recreational Vessels less than 79 feet (EPA, 2010), a comprehensive analysis was made of bilgewater discharges from small commercial vessels including fishing vessels, tow/salvage vessels, water taxis, and tour vessels. Among the metals detected in bilgewater, dissolved copper, selenium, and zinc, as well as total arsenic, were consistently measured at concentrations exceeding the most stringent national recommended water quality criteria from several vessel classes. The classical pollutants BOD5, sulfide and total suspended solids (TSS) were found at potentially significant concentrations in bilgewater from fishing vessels, tow/salvage vessels, water taxis, and tour vessels. Among several pathogen indicators, enterococcus was present at concentrations exceeding quality limit values in bilgewater samples collected from fishing boats. Total phosphorus exceeded a screening benchmark for nutrients. Concentrations of the semivolatile organic chemical (SVOC) bis (2-ethylhexyl) phthalate exceeded limit values in the bilgewater discharges of fishing vessels, tow/salvage vessels, water taxis, and tour vessels. Benzene sampled in bilgewater from tow/salvage vessels was the only VOC found at concentrations exceeding the most stringent limit values.

Plovila koja instaliraju sertifikovane separatore kaljužne vode koji se trenutno nalaze na tržištu i savesno ih održavaju, trebala bi biti u stanju ispuniti standard prečišćavanja od 15 ppm, uprkos mogućim poteškoćama. Moguće je i ispunjavanje standarda od 5 ppm ulja za prečišćavanje kaljužne vode, iako to zahteva dodatnu posvećenost sticanju i održavanju efikasnosti separatora kaljuže, uz poštovanje "najbolje prakse" i smernica koje su date od strane Međunarodne pomorske organizacije / Odbor za zaštitu morske životne sredine (IMO) / MEPC) - Praksa integrisanog sistema za tretman kaljužnih voda (IBTS) (IMO / MEPC 2008).

Svi ovi separatori kaljužne vode su sistemi za tretman koji kombinuju gravitacioni separator zauljene vode (OWS) ili centrifugu sa jednim ili više dodatnih operacija za smanjenje koncentracije emulgovanog ulja. Jedinice koje se dodaju OWS / centrifugalnim sistemima za prečišćavanje kaljužne vode uključuju:

- Apsorpciju i adsorpciju,
- Biološki tretman,
- Koagulaciju i flokulaciju,
- Flotaciju, i
- Ultrafiltraciju.

TRETMAN BALASTNIH VODA

Prema Konvenciji IMO o upravljanju balastnim vodama (BVM), svi brodovi u međunarodnom saobraćaju moraju upravljati svojom balastnom vodom i sedimentima prema određenom standardu, prema planu upravljanja balastnim vodama specifičnim za brod. Svi brodovi će takođe biti u obavezi da imaju evidenciju balastnih voda i međunarodni sertifikat za upravljanje balastnim vodama. Standardi upravljanja balastnim vodama će se postepeno uvoditi u određenom vremenskom periodu. Međutim, na kraju će većina brodova morati da instalira sistem za prečišćavanje balastnih voda (IMO 2017).

Postoje dve vrste tehnoloških procesa koji se koriste za prečišćavanje balastnih voda: separacija ili separacija čvrsto tečno, koja uključuje odvajanje suspendovanih čestica iz balastnih voda sedimentacijom ili površinskom filtracijom i dezinfekcijom, u cilju uklanjanja mikroorganizama fizičkim ili hemijskim metodama. Često se dezinfekcija vrši UV-lampama koje deluju na DNK mikroorganizama putem denaturacije i na taj način sprečavaju njihovu proliferaciju.

Balastna voda se može filtrirati i pre skladištenja u balastnim tankovima ili u ispustima u more. Filtracija je veoma koristan metod i ima brojne prednosti. Jedna od prednosti filtracije pri punjenju balasta je da se zadržani organizmi mogu vratiti u svoje prirodno stanište. Ako se balastna voda filtrira pri ispuštanju, potrebno je obezbediti odgovarajuće skladište za uhvaćene organizme, kako bi se uklonila mogućnost kontaminacije vode u koju se balast oslobađa. Međutim, sa svim prednostima, postoje određeni nedostaci kada je u pitanju filtriranje balastne vode.

Vessels that install certified bilge separators currently on the market, and operate and maintain them conscientiously, should be able to meet a 15 ppm discharge standard, despite the possible difficulties. Meeting 5 ppm oil standards for bilge discharge is also possible, although it requires additional commitment to acquiring and maintaining effective bilge separators, along with adhering to "best practices "and guidance such as the International Maritime Organization / Marine Environment Protection Committee (IMO / MEPC) Integrated Bilgewater Treatment System (IBTS) practices (IMO / MEPC, 2008).

All of these bilge separators are treatment systems that combine a gravity oil-water separator (OWS) or centrifuge with one or more additional unit operations that "polish" the bilgewater effluent to reduce concentrations of emulsified oil. Unit operations that are added to OWS/centrifuge-based bilge separator systems include:

- Absorption and Adsorption,
- Biological Treatment,
- Coagulation and Flocculation,
- Flotation, and
- Ultrafiltration.

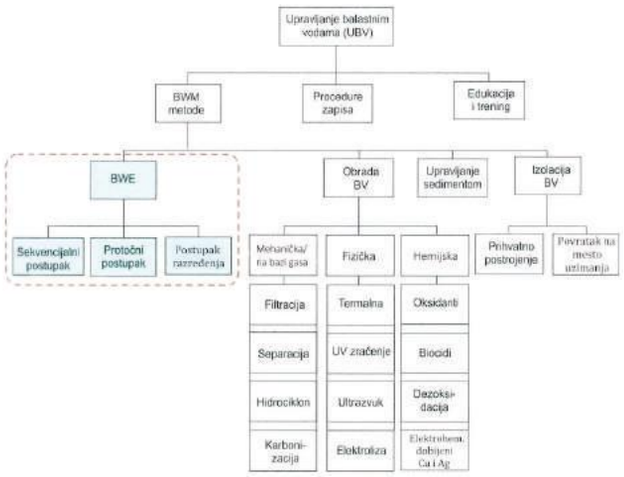
BALLAST WATER TREATMENT

Under the IMO Ballast Water Management (BWM) Convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. All ships will also have to carry a ballast water record book and an international ballast water management certificate. The ballast water management standards will be phased in over a period of time. However, eventually most ships will need to install an on-board ballast water treatment system (IMO, 2017).

There are two types of technological processes used for ballast water treatment: separation or separation solid-liquid, which involves the separation of suspended solids from ballast waters by sedimentation or surface filtration and disinfection aimed at the removal of microorganisms by physical or chemical methods. Often, disinfection is done by UV lamps acting on DNA microorganisms by denaturing and thus preventing their proliferation.

Ballast water can also be filtered before it is stored in ballast tanks or in discharges into the sea. Filtration is a very useful method and has a number of advantages. One advantage of filtration when filling ballast tanks is that retained organisms can return back to their natural habitat. If ballast water is filtered at discharge, a suitable storage for captured organisms should be provided to eliminate the possibility of contamination of the water into which the ballast is released. However, with all the advantages, there are certain disadvantages when it comes to the filtration of ballast water. One major lack of filtration is that

Jedan veliki nedostatak filtracije je taj što proces zahteva posebne uređaje koji mogu biti skupi za kupovinu i instalaciju.



Slika 2. Shematski prikaz metoda upravljanja balastnim vodama (Trivić 2016)

the process requires special devices that can be expensive to purchase and install.

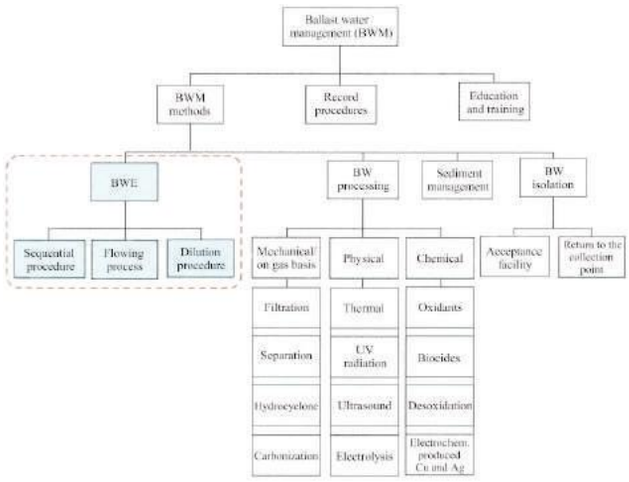


Figure 2. Schematic diagram of ballast water management methods (Trivić 2016)

TRETMAN SANITARNE OTPADNE VODE

Optimalan rad uređaja zasniva se na pravilno odabranoj vrsti hemikalija i dozi u kojoj se primenjuju (koagulant, flokulant, sredstvo za korekciju pH), što je prethodno definisano implementacijom tzv. "Jar" testa u laboratorijskim uslovima, a zatim proveru rada uređaja pre zvaničnog puštanja u rad.

Proces prečišćavanja sanitarne otpadne vode obuhvata sledeće tehnološke faze (procese):
— Filtracija sirove otpadne vode,
— Strujanje i racionalizacija sastava (kvaliteta),
— Odvajanje ulja i plutajućih supstanci,
— Podešavanje pH (neutralizacija) i koagulacija,
— Flokulacija, taloženje, flotacija
— Ekstrakcija zaostalih nečistoća
— Prihvatanje prečišćene vode, kontrola kvaliteta i ispuštanje u recipijent.

U procesu prečišćavanja vrši se doziranje rastvora hemikalija za procese neutralizacije (kiselina, baza), koagulacije (soli gvožđa ili aluminijuma) i flokulacije (polielektroliti). Nakon tretmana otpadne vode, nastala količina mulja se skladišti u kontejnerima do njihovog popunjavanja, nakon čega se predaju ovlašćenom operatoru na dalji, zakonski dozvoljen tretman ili ako se, ako postoji odgovarajući uređaj za tretman, prebacuje u uređaj na dalji tretman, na samom brodu.

NAPREDNI SISTEMI ZA PREČIŠĆAVANJE OTPADNIH VODA (ADVANCED WASTEWATER TRE*ATMENT SYSTEMS - AWT)*

Savremeni kruzeri poštuju propise koji se odnosed na zaštitu životne sredine, pa shodno tome u

SANITARY WASTEWATER TREATMENT

Optimal operation of the device is based on the properly selected type of chemicals and the dosage in which they are applied (coagulant, flocculant, pH correction agent), which is previously defined by the implementation of the so-called "Jar" test in laboratory conditions, and then checking of device operation before official commissioning.

The process of purification of sanitary wastewater includes the following technological phases (procedures):
— Filtration of raw wastewater,
— Streaming and streamlining of composition (quality),
— Separation of oils and floating substances,
— Adjustment of pH (neutralization) and coagulation,
— Flocculation, precipitation, flotation
— Extraction of residual impurities
— Acceptance of purified water, quality control and discharge into the recipient.

In the purification process, dosing of the solution of chemicals for the processes of neutralization (acid, base), coagulation (iron or aluminum salts) and flocculation (polyelectrolyte) is carried out. After the treatment of wastewater, the resulting quantity of sludge is stored in containers until it is filled, after which it is delivered to the authorized operator for further, legally approved processing, or if there is an appropriate treatment device, it is transferred to the device for further treatment, alone ship.

ADVANCED WASTEWATER TREATMENT SYSTEMS

On some cruise vessels sanitary ()black and

svom sastavu imaju ugrađene napredne sisteme za tretman sanitarnih (crnih i sivih) otpadnih voda tzv. *Advanced Wastewater Treatment systems* (AWTs), dok su stariji modeli brodova u obavezi da obavljaju prepumpavanje u lučke prihvatne uređaje (EPA 2008). AWT generalno obezbeđuju poboljšanje biološkog tretmana, odvajanja čvrstih čestica (korišćenjem filtracije ili flotacije) i dezinfekcije (korišćenjem ultraljubičaste svetlosti), u poređenju sa tradicionalnim sistemima za tretman otpadnih voda. Membranski bioreaktorski (MBR) sistem koristi aerobni biološki tretman, obično sa produženom aeracijom (Molland 2008), nakon čega sledi ultrafiltracija i ultraljubičasta (UV) dezinfekcija. Otpadna voda se prvo tretira kroz sito da bi se uklonio papir i drugi krupni materijali. Zatim, otpadna voda ulazi u dvostepeni bioreaktor, gde bakterije razgrađuju organsku materiju. Nakon biološke obrade, otpadna voda se filtrira kroz cevaste ultrafiltracijske membrane da bi se uklonile čestične materije i biološka masa, koja se vraća u bioreaktore. U završnoj fazi tretmana, otpadna voda se podvrgava UV dezinfekciji radi smanjenja patogena. Rezultati uzorkovanja pokazuju da su AWT veoma efikasni u uklanjanju patogena, supstanci koje zahtevaju potrošnju kiseonika, suspendovanih čestica, ulja i masti i rastvorenih metala (37 do 50%). Većina isparljivih i poluisparljivih organskih jedinjenja se uklanjaju do nivoa ispod granica detekcije, dok ostale pokazuju umereno uklanjanje. AWT postižu umereno uklanjanje hranljivih materija, verovatno kao rezultat unosa hranljivih materija od strane mikroorganizama u bioreaktorima.

ZAKLJUČAK

Štetni uticaji na životnu sredinu koji potiču od otpadnih voda s brodova i uopšte nastali kao posledica brodskog transporta, mogu se podeliti u četiri kategorije: fizičke, termičke, hemijske i biološke. Moguće termičke i biološke opasnosti mogu nastati usled prisustva velikih količina različitih vrsta otpadnih voda. Problemi se takođe javljaju i usled štetnih efekata invazivnih vrsta koje se nalaze u rezervoarima za balastnu vodu. Zagađujuće materije iz kaljužne vode mogu imati toksične, korozivne, zapaljive ili eksplozivne karakteristike.

Separatori zauljene kaljužne vode uglavnom se zasnivaju na sistemu za tretman koji kombinuje gravitacioni separator ulja (OVS) ili centrifugu sa jednom ili više dodatnih operacija koje smanjuju koncentraciju emulgovanog ulja. Sistem za tretman sanitarne (crne i sive) otpadne vode sastoji se od pet osnovnih faza: faza predtretmana, biološki tretman mikroorganizama, flokulacija i flotacija, faza finog filtriranja, završna obrada UV zračenjem. Jedno od savremenih rešenja za tretman sanitarnih voda zasniva se na MBR. Postoji veliki broj modernih bioloških postrojenja za prečišćavanje otpadnih voda, ali se većina njih zasniva na produženom procesu aeracije.

gray water) are often treated using AWTs. AWTs generally provide improved biological treatment, solids separation (using filtration or flotation), and disinfection (using ultraviolet light) as compared to traditional waste water treatment systems. The AWTs currently used by cruise ships operating in Alaskan waters are discussed in this subsection. Membrane Bioreactor (MBR) system uses aerobic biological treatment, usually with extended aeration (Molland 2008), followed by ultrafiltration and ultraviolet (UV) disinfection. Wastewater is first treated in screen presses to remove paper and other coarse solids. Next, the wastewater enters a two-stage bioreactor, where bacteria digest the organic matter in the waste. Following biological treatment, the wastewater is filtered through tubular ultrafiltration membranes to remove particulate matter and biological mass, which are returned to the bioreactors. In the final stage of treatment, the wastewater undergoes UV disinfection to reduce pathogens. Sampling results, indicate that AWTs are very effective in removing pathogens, oxygen demanding substances, suspended solids, oil and grease, and dissolved metals (37 to 50%). Most volatile and semi-volatile organics are removed to levels below detection limits, while others show moderate removal. AWTs achieve moderate nutrient removals, likely resulting from nutrient uptake by the microorganisms in the bioreactors.

CONCLUSIONS

Harmful environmental impacts deriving from wastewater from ships and generally derived from shipping, can be divided into four categories: physical, thermal, chemical and biological. The potential thermal and biological hazards can occur due to the presence of large amounts of different types of waste wate. Problems also occur due to the adverse effects of invasive species found in ballast water reservoirs. Polluting substances from bilge water may have toxic, corrosive, flammable or explosive properties.

Oily bilge water's separators mostly are based on treatment system that combines a gravity oil separator (OVS) or a centrifuge with one or more additional operations that reduce the concentration of emulsified oil. Treatment system for sanitary (black and gray) waste water, consists of five basic phases: pre-treatment phase, biological treatment of microorganisms, flocculation and flotation, fine filtration phase, final treatment with UV rays. One of the modern solutions for treatment of bilge water, sludge and ballast water is based on a MBR. There is a large number of modern biological waste water treatment plants, but most of them are based on the extended aeration process.

There are two types of technological processes used for ballast water treatment: separation or separation solid-liquid which involves the separation of suspended solids from ballast waters by

Postoje dve vrste tehnoloških procesa koji se koriste za tretman balastnih voda: separacija ili separacija čvrsto / tečno, koja uključuje odvajanje suspendovanih materija iz balastnih voda sedimentacijom ili površinskom filtracijom i dezinfekcijom (uglavnom UV).

Primenom sistema za prečišćavanje otpadnih voda sa brodova, navedenih u ovom radu, kao rezultat se dobija prečišćena voda, potpuno u skladu sa propisima i apsolutno sigurna za ispuštanje u životnu sredinu, što konačno rezultira očuvanjem čistih vodnih tela i vodenih ekosistema.

sedimentation or surface filtration and disinfection (mostly UV).

The outcame of the application of wastewater treatment from the ships listed in this paper are purified waste water, completely in accordance with the regulations and absolutely safe for discharge into the environment, finally resulting with preserving clean water bodies and aquatic ecosystems.

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