IMPACT OF SHIP'S BALLAST WATER ON INVASIVE SPECIES OCCURRENCE, AND AS A CONSEQUENCE ON ENVIRONMENTAL AND PUBLIC HEALTH: A SHORT REVIEW

A. Kholdebarin^{1*}, N. Mozaffari², V. Vambol³, S. Vambol⁴, N. Mozaffari²

¹Trier University, Trier, Germany

²Science and Research Branch, Islamic Azad University, Tehran, Iran

³Public Agency "National Scientific and Research Institute of Industrial Safety and Occupational Safety and Health", Kiev, Ukraine

⁴Kharkiv Petro Vasylenko National Technical University of Agriculture, Kharkiv, Ukraine

*Corresponding email: atefekhholdebarin@yahoo.com

Received: 5 March 2020; Accepted: 30 March 2020

Cite as: Kholdebarin, A., Mozaffari, N., Vambol, V., Vambol, S., Mozaffari, N. (2020). Impact of ship's ballast water on invasive species occurrence, and as a consequence on environmental and public health: a short review. *Labour Protection Problems in Ukraine*, 36(1), 18-21.

Water is one of the main ways of transportation. The reduction of water pressure on the ship hull, controlling ship submergence, compensate for the impact of losing weight from fuel or water consumption, help to the existence of lateral balance and stability are the factors that show all ships need ballasting. Ballast water contains a large number of organisms from different species, which are in different life stages (egg, Larvae, Cysts, Spores, or adult). These aquatic invasive species cause damage to fisheries, aquaculture, water supply system, industrial infrastructure, biodiversity, and habitat. The study aims to review open information sources and analyze them to identify the Impact of ship's ballast water on invasive species occurrence, and as a consequence on environmental and public health effects. The search for sources was carried out for the keywords «ballast waters», «ecology», «environment», «public health» and «invasive species», as well as for various combinations of these words through the Google Scholar. Restrictions in the search for sources amounted to: since 2005 and in relevance. The features of one of the reasons for the spread of invasive species and negative environmental consequences for aqua systems and public health are studied. The study's practical value lies in the fact that the study results can be used to train workers from water transport and ensure the environmental safety of aqua systems. Predation, parasitism, competition, the introduction of new pathogens, genetic changes, habitat alterations, species shift, and loss of biodiversity are the most important ecological impacts. Exotic species, which are often brought with ballast water, cause change to ecosystem function by changing in a nutrient cycle and a decrease in water quality. It is established that some invasive species including *Vibrio Cholera* and *Giardia duodenalis* that are transported by ballast water also affect the public health by increasing the risk of pathogens and parasitism.

Keywords: water transport, ballast water, invasive species, environmental, public health

ВПЛИВ СУДНОВИХ БАЛАСТНИХ ВОД НА ПОЯВУ ІНВАЗИВНИХ ВИДІВ І, ЯК НАСЛІДОК, НА СТАН ДОВКІЛЛЯ І ЗДОРОВ'Я НАСЕЛЕННЯ: КОРОТКИЙ ОГЛЯД

A. Кхолдебарін^{1*}, Н. Мозаффарі², В. Вамболь³, С. Вамболь⁴, Н. Мозаффарі²

¹Трірський університет, Трір, Німеччина

²Науково-дослідний відділ, Ісламський університет Азад, Тегеран, Іран

³Державна установа «Національний науково-дослідний інститут промислової безпеки та охорони праці», Київ, Україна

⁴Харківський національний технічний університет сільського господарства імені Петра Василенка, Харків, Україна

*E-mail для листування: atefekhholdebarin@yahoo.com

Отримано: 5 Березня 2020; Прийнято: 30 Березня 2020

Цитувати як: Kholdebarin, A., Mozaffari, N., Vambol, V., Vambol, S., Mozaffari, N. (2020). Impact of ship's ballast water on invasive species occurrence, and as a consequence on environmental and public health: a short review. *Labour Protection Problems in Ukraine*, 36(1), 18-21.

Водні шляхи сполучення активно використовують для різних видів перевезень. І тут дуже важливо забезпечити стійкість судна на плаву для його безпеки. Для цього необхідно враховувати зміну тиску води на корпус судна, контроль глибини його занурення (осадку), а також компенсацію зниження ваги через витрачання палива або води, необхідність забезпечення бічного балансу і стійкості – як факторів, що впливають на баластування будь-якого судна. В якості рідкого баласту для баластування використовуються баластні води. Баластна вода містить велику кількість живих організмів різних видів, які знаходяться на різних стадіях життя (яйце, личинки, цисти, спори або дорослі особини). Ці водні інвазивні види завдають шкоди рибному господарству, аквакультурі, системі водопостачання, промисловій інфраструктурі, біорізноманіттю та середовищу проживання. Мета дослідження – вивчити відкриті джерела інформації та проаналізувати їх, щоб визначити вплив суднових баластних вод на появу інвазивних видів і, як наслідок, вплив цих видів на довкілля і здоров'я населення. Пошук джерел здійснювався за ключовими словами «баластна вода», «екологія», «довкілля», «громадське здоров'я» та «інвазивні види», а також за різними комбінаціями цих слів за допомогою Google Scholar. Обмеження в пошуку джерел: період із 2005 року; за релевантністю. Вивчено особливості однієї з причин поширення інвазивних видів і екологічно негативних наслідків для водних систем і здоров'я населення. Практична цінність дослідження полягає в тому, що результати дослідження може бути використано для навчання працівників водного транспорту та забезпечення екологічної безпеки водних систем. Хижацтво, паразитизм, широке використання нових патогенних мікроорганізмів, генетичні зміни, зміни середовища проживання, зміна виду і втрата біорізноманіття є найбільш важливими екологічними впливами. Екзотичні види живих організмів, які часто доставляються з баластною водою, спричиняють зміни у функціонуванні екосистем, змінюючи кругообіг поживних речовин і знижуючи якість води. Встановлено, що деякі інвазивні види, що переносяться баластною водою, також впливають на здоров'я населення, збільшуючи ризик виникнення паразитизму і патогенних мікроорганізмів. До них, наприклад, відносяться *Vibrio Cholera* і *Giardia duodenalis*.

Ключові слова: водний транспорт, баластна вода, інвазивні види, довкілля, здоров'я населення.

1. Problem statement and analysis of the recent researches and publications.

River, sea, and oceans cover the vast area of the earth's surface. Importance of water and the need for water lead

human settlement along the coastal region. Water is one of the main ways of transportation. According to the International Marine Organization (IMO) in 2008 «more than 90 % of all worldwide trade goods are transported on the ocean».

Civilization, trade, and transportation cause increase in ship size and speed, and increase the likelihood of invasive species occurrence [1]. When the ship's cargo is loaded and unloaded, it requires ballasting. The reduction of water pressure on the ship hull, controlling ship submergence, compensate for the impact of losing weight from fuel or water consumption, help to the existence of lateral balance and stability are the factors that show all ships need ballasting. This balance is obtained by pumping water in the ballast tank or transferring water out of the tank [2].

In earlier centuries, solid materials, like stone and rocks are used instead of water to maintain their balance in the water, but this dry matter causes several problems such as instability, time-consuming, and need labour force, for loading and unloading of these dry matters [3].

The introduction of invasive species from ship ballast water has large, environmental, ecological, and socio-economic impacts. This phenomenon will cause the extinction of some endemic species [4].

Ballast water contains a large number of organisms from different species. These species are in different life stages (egg, Larvae, Cysts, Spores, or adult). Ships fill their ballast tank near the port, which is shallow and has high turbidity. So, different species in different life stage can pump in the ballast tank. Moreover, the turbid water causes high sedimentation in the ballast tank and provides a suitable condition for the transportation of Dinoflagellates Cysts [1].

It should be mentioned that the size of the organism that can be in ballast water during pumping of water inside the tank depends on the method of ballasting and the size of «intake screens». These organisms are intake in source port into the ballast tank and then pumped out of the tank in the destination port, and because they are not endemic species in the second port, they count as invasive species [5].

These aquatic invasive species cause damage to fisheries, aquaculture, water supply system, industrial infrastructure, biodiversity, and habitat [5]. Based on published estimation, more than 10000 marine species move around within ballast water. It is obvious that by increasing the size and speed of ships the survival chance of tank species is increased, and a higher number of species successfully introduce to new habitats [5].

In addition to ballast water, a different part of ships like Vessel, hull, sea chest, and anchor chain can also be a pathway [6]. Besides, unintended entrance with ballast water or hull fouling, Natural dispersal, and deliberate entrance are other different pathways and vectors to transfer marine invasive species [1, 6].

It is obvious that we have high mortality among species in the ballast water tank due to physical damage. Moreover, species that need light for photosynthesis to survive cannot tolerate the ballast tank darkness. On the other hand, many other species are survived and threatened the endemic species lives in the destination port. Comb jelly entrance to Black sea or Zebra mussel entrance to American Great lakes are examples of these claims [1].

Harmful invasive species have different characteristics like their ability to change the food web, cause for boat system, infrastructure, and pipes, and reproduce as well as grow rapidly in destination habitat. Also, they cause endemic fish's mortality or threat aquaculture because of their pathogenic effects [7].

Thus, this study aims to review open information sources and analyze them to identify the Impact of ship's ballast water on invasive species occurrence, and as a consequence on environmental and public health effects.

2. Statement of the problem and its solution.

2.1 Materials and methods.

In this study open information sources from the Internet through the Google Scholar were used. The search for sources was carried out for the keywords «ballast water»,

«ecology», «environment», «public health» and «invasive species», as well as for various combinations of these words. Restrictions in the search for sources amounted to: since 2005 and in relevance.

2.2. Results and Discussion.

2.2.1. Impact of invasive species.

The impact of invasive species is categorized as ecological effects, economic impact, and public health concern.

Ecological impacts. Predation, parasitism, competition, the introduction of new pathogens, genetic changes, habitat alterations, species shift, and loss of biodiversity are the most important ecological impacts. In total, loss of biodiversity can have several reasons, but according to the different studies, habitat degradation and introduced species are the main reasons for biodiversity degradation [1, 3].

Different countries around the world face an exotic species entrance. Countries like Australia, Russia, US, and European countries have this problem. Exotic species cause change to ecosystem function by changing in a nutrient cycle and a decrease in water quality. The water hyacinth phenomenon happened with invasive species, and it is one of the main problems in Africa and southeast Asia. Therefore, because of the ecological impact, the water surface is covered by a dense cover of algae and plants. This dense cover causes the amount of oxygen decline, reduce light penetration to deeper part, and also causes a problem for ships, and boat movement, decrease fisheries industries and plug pipes and infrastructure [1, 3].

Moreover, this plant cover is a suitable place for pathogens and different insects to live and lay eggs that threaten public health. This hyacinth consumes most of the water nutrients and causes endemic fishes mortality due to lack of food, and the degradation of hyacinth plants lead the water to Eutrophic steps as well [1].

According to the published article, areas with a different number of invasive species are exposed to high risk [8]. In this case, the important invasive species carried by ship ballast water are *Zebra mussel*, *Chinese mitten crab*, *European green crab*, *Round gabby*, *Comb jelly*, *North pacific sea star*, and *Red mysid shrimp*.

Zebra mussel with a sharp shell lives in Black, Caspian, and the Aral Sea. It spreads in ballast water to the US in North America. Its capability to attach to the shells or the surfaces of other species to kill them and its mussel attachment to boat hulls that cause overuse of fuel and energy, and consequently technical problem for ship functions due to dragging and clogging engines, are zebra mussel properties. Besides, it increases the competition of native mussels and other filter feedings. In the environment, Zebra mussels have a different impact on water quality. This species is a filter feeder, that is, they suck the water through their siphon to digest nutrient and organic matter that makes residues eject in the marine environment. This residue is covered with special mucus that is harmful and toxic for native species. As a result, the filter-feeding characteristic of Zebra Mussels causes water to be clearer. This clearance let the sunlight to penetrate deeper into the water, increase the photosynthesis, warmer water column, Thermo cline drops, and increase Epilimnion thickness. In total, this species makes the habitat unsuitable for endemic species and finally causes the extinction of endemic fisher because of lack of food like Phytoplankton, Zooplanktons [9, 10].

Chinese mitten crab threatens the «Salmonid eggs and Larvae» by consuming them or threats them due to creating the unsuitable condition. This species can be found in the North Sea, Baltic Sea, Atlantic, and Pacific coast. It has «burrowing habits» and causes erosion and clogging industrial water systems [7]. It can multiply and spread at a very fast rate and also can cross dry land. The mitten crab creates «burrows in muddy river banks» which increases erosion and «silt loading» in the rivers and can lead to bank collapse [11].

European green crab causes damage and destruction to «Juvenile Clam» that has soft-shell. It also feeds upon aquaculture stock and reduces fisheries industries that

apparently decrease the number of endemic species [1, 12]. *Round goby* comes from the Black and Caspian Seas to Europe and the United States. This species is aggressive and feeds on the eggs and young of other fish species that reduce the amount of them. It has also the ability to survive in poor quality water [3]. *Comb jellies* lives in North America and enter the Black Sea, the North Sea, and the Caspian Sea, and causes problem and damage to local fisheries industries and Mariculture by prey on fishes' larvae [1].

North pacific sea star can tolerate different temperatures and wide ranges of salinities and it has wide feeding range. This species originally found in far North Pacific waters and areas surrounding Japan, Russia, North China, and Korea, the northern Pacific. It feeds on «handfish» egg, and «sea squirts». The sea star settling on «scallop longlines», «spat bags», «mussel and oyster lines» and «salmon cages», and finally reduces the fisheries industry production [13]. Furthermore, *Red mysid shrimp* lives in the Black Sea and the Caspian Sea in fresh and brackish water, but presently it is an invasive species in the Baltic Sea, North Sea and Rhine River, United States and Scandinavia. This species feeds on Zooplankton and Algae and reduces the number and growth rate of «pelagic» fishes [7, 14].

Economic impacts. The industrial water consumers, levees and dams' damages, and fishing in terms of commerce and recreation, and industries of Mariculture are the economic impact of invasive species [3]. Algae and fouling caused damage to infrastructure and increase the cost of treatment, clean up, and maintenance, more importantly, its tourism attraction will be lost [1].

Public health concerns. Some invasive species that transport by ballast water are also influences public health by increasing the risk of pathogens and parasitism. Different types of bacteria and viruses like *Vibrio Cholera* and *Giardia duodenalis* can cause public health [7]. Moreover, «Cholera risk», «Algal bloom» and «Shellfish poisoning» are the main cause of public health concern [3]. *Vibrio cholera* can transfer to the human body by polluted water and eating seafood. It should be mentioned that changing in ship industries and change solid ballast to water ballast water increase the spread of invasive species [1, 15].

In addition to ballast water that is the main pathway, Biofouling that occurs on vessels, anchors, and ship bodies is another vector for invasive species transportation. This vector provides a means for both «sessile and mobile organisms» [1, 16]. Given published article [3, 17], the creation of biofouling has four steps and in each step, the rate of complexity becomes higher, and macroscopic fouling is created, and finally, at the end of the fourth step, three layers are created. The creation of biofouling takes months or more, and then these biofoulings are transported by ships to different ports and cause an environmental problem for native species [17].

Moreover, «No Ballast on Board» ships still can be a vector for invasive species due to the sediments that accumulate in their ballast tank. When NOBOB ships pump the ballast water, this water mix with residual sediments and increase the possibilities of different microorganism's transportation with different life stage that exist in the sediments [3].

2.2.2. Treatment.

In order to reduce the risks of invasive species in ballast water, several strategies and methods have been developed that are mentioned as follows. In total reducing the risk need monitoring, education, management, policies, strategies and framework in national and international level [1]. The main measures that prevent the transfer of invasive species by ballast water are:

- Reduction in the amount of ballast water intake in shallow and turbid water. Especially should reduce it at night, because organisms migrate vertically to feed at night, and pumping the water at night increases the risk of species intake to the tank.

- Purification the ballast water tank and removal the sediments.

- Drain ballast water only when it is absolutely necessary
- Using another method of ballast water exchange. For example, water can be exchanged in mid-ocean or deeper water.

- Treatment of ballast water. Different treatments can be applied like mechanical treatment, physical treatment and chemical treatment or combination of them.

- Using special receptors to discharge ballast water in, and do not discharge it directly to nature [1].

In addition, there is also a «pretreatment» and «end treatment» for ballast water. In the first step, a filter is used during ballasting to remove large number of organisms and suspended sediments, and then the main treatment is accomplished to reduce the amount of organisms on the filter. Finally, at the end of the voyage, the ballast water is again subjected to repeat treatment [7]. The method could be mechanical (filtration or separation), physical (Ozone, UV, heat), or chemical (biocides), and most of the time the combination of methods is more effective [18].

With *Filtration* method, zooplankton, and larger phytoplankton can be filtered, but this method is not reliably reducing all of the microorganisms, and it is more effective for separation of larger organisms by using cyclonic separator as second treatment, or by «inactive» the bacteria or viruses. Microorganism and bacteria DNA is destroyed by using *ultraviolet light*. This method is an effective technology to treat ballast water [3]. *Biocides* can effectively kill microorganisms, viruses, and bacteria. Moreover, chlorine is also a good disinfectant. But this method can cause a different problem, for example, the unknown reaction of Biocides with seawater can cause a problem. Also, it causes corrosion in the tank. Moreover, the high dose of these materials is needed for treatment, which is caused by toxic discharge in the destination port [3, 6]. This method will cause «disinfection by-products (DBPs)» that are an unwanted product from a chemical reaction and can be toxic and harmful for marine species [19]. According to the *deoxygenation* method, Nitrogen gas is injected to ballast water as bubbles, and cause to decrease in the amount of oxygen, therefore most microorganisms cannot survive due to lack of oxygen. However, *thermal treatment* is not reliable and also causes corrosion, and increase the growth rate of special algae that can survive in high temperature [19].

According to the *mid-ocean exchange* that is suggested by USCG 2003, invasive species are reduced as they exchange in the mid-ocean that has a higher salinity than coastal waters. This high salinity can be lethal for some species [21]. According to this method, this exchange should happen at «distance greater than 200 nautical miles from shore, and in water greater than 500 meters deep». One the other hand, mid-ocean exchange method has several drawbacks such as not applicable for all ships, not safe in unsuitable weathering condition, not effective for the species that tolerate saline water, and the probability of the survival of organisms by escaping from being flushed and hide in the ballast water tank sediments [6]. According to this method, ships replace their lower-salinity coastal water with higher salinity open ocean water and oceanic species are replaced by coastal species that cannot tolerate high salinity of mid-ocean water; so, ballast water species are reduced. Moreover, oceanic species also need more salinity; therefore, they also died when discharged in coastal water with less salinity [6].

Conclusion and recommendations.

1. Ballast water causes invasive species. As a result, there is a change to ecosystem function by changing in a nutrient cycle and a decrease in water quality and an increased risk for the spread of parasites and viruses.

2. It is established that some invasive species including *Vibrio Cholera* and *Giardia duodenalis*, that are transported by ballast water also affect the public health by increasing the risk of pathogens and parasitism.

3. In order to reduce invasive species in ballast water, some recommendations must be followed, such as:

- Reduction in the amount of ballast water intake in shallow and turbid water, especially at night;
- Purification of the ballast water tank and removal of the sediments, and etc.

4. Since the considered problem of the negative impact of ballast water on ecosystems and public health is relevant, it is necessary to search for the new methods of using and purifying ballast water or the new methods of vessel stability afloat.

Acknowledgements.

The authors are grateful to the administration of Public Agency «National Scientific and Research Institute of Industrial Safety and Occupational Safety and Health» for the opportunity to publish this study.

Conflicts of Interest.

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or article publication.

REFERENCES

1. Tamelander, J., Riddering, L., Haag, F., Matheickal, J., No, G. M. S. (2010). *Guidelines for development of a national ballast water management strategy*. GloBallast Partnerships Project Coordination Unit, International Maritime Organization. Available: http://archive.iwlearn.net/globallast.imo.org/wp-content/uploads/2015/01/Monograph_18_web.pdf.
2. Ultrasonic Ballast Water Disinfection. Available: www.hielscher.com/ultrasonic-ballast-water-disinfection.htm.
3. Christopher, F. D., Richard, C. R. (2002). Ballast water and introduced species: Management Options for Narragansett Bay and Rhode Island. *Narragansett Bay Estuary Program, RI Department of Environmental Management*, 2002.
4. Kim, L., Eckford-Soper, L., Pedersen, K.L., Henrik, H. (2019). Development of a novel automated analytical method for viability assessment of phytoplankton used for validation of ballast water treatment systems. *Journal of Applied Phycology*, 31, 2941–2955.
5. Henrik, H., Knud, L., Kim, L. (2016). Verification of the effectiveness of ballast water treatment system. Available: [https://www.sdu.dk/-/media/files/om_sdu/institutter/iti/blue+sdu/ballast+water+project+for+bluesdu+website_sept+2016+\(1\).pdf](https://www.sdu.dk/-/media/files/om_sdu/institutter/iti/blue+sdu/ballast+water+project+for+bluesdu+website_sept+2016+(1).pdf).
6. Aquatic nuisance species in ballast water discharges: Issues and Options, draft for public comment – September 10, 2001. *Prepared by: U.S. Environmental Protection Agency Office of Water; Office of Wetlands, Oceans and Watersheds; Office of Wastewater Management, Washington, DC*.
7. Battle, J. (2009). Silent Invasion—the spread of marine invasive species via ships' ballast water. *World Wildlife Fund International, Gland, Switzerland*.
8. Diaz-de-Leon, A., Mondragón, S.D. (2013). Marine Spatial Planning and LMEs in Mexico. In book: *Stress, Sustainability and Development of Large Marine Ecosystems during Climate Change: Policy and Implementation*. Edition: Publisher: Large Marine Ecosystems GEF-UNDP, Editors: Kenneth Sherman, 18, 95–105.
9. Zebra mussels first appeared in Lake St. Clair. Available: <https://www.lakeproinc.com/zebra-mussels-first-appeared-lake-st-clair>.
10. Yauck, J. (2009). Little quagga mussel has big impact on Lake Michigan. Available: <https://bayviewcompass.com/little-quagga-mussel-has-big-impact-on-lake-michigan>.
11. Herborg, L.M., Rushton, S.P., Clare, A.S., Bentley, M.G. (2003). Spread of the Chinese mitten crab (*Eriocheir sinensis* H. Milne Edwards) in Continental Europe: analysis of a historical data set. In: Jones M.B., Ingólfsson A., Ólafsson E., Helgason G.V., Gunnarsson K., Svavarsson J. (eds) *Migrations and Dispersal of Marine Organisms. Developments in Hydrobiology*, 174. Springer, Dordrecht. Available: https://doi.org/10.1007/978-94-017-2276-6_3.
12. Learn About Crabs & Relatives: Habitat & community ecology, Research study 13: Invasive green crabs *Carcinus maenas*. Available: <http://www.asnailsodyssey.com/LEARNABOUT/CRUSTACEA/crabComp2.php>.
13. Byrne, M., Morrice, M.G., Wolf, B. (1997). Introduction of the northern Pacific asteroid *Asterias amurensis* to Tasmania: reproduction and current distribution. *Marine Biology*, 127(4), 673–685.
14. Freda, W., Ombra, Z. (2012). Maritime transport—an environmental problem with ballast water: technical preventive measures. *Journal of KONES*, 19, 153–158.
15. News Deck (2017). Paralytic shellfish poison levels force recreational harvest ban, Available: <https://www.foodsafetynews.com/2017/08/paralytic-shellfish-poison-levels-force-recreational-harvest-ban/>.
16. Fernandes, J.A., Santos, L., Vance, T., Fileman, T., Smith, D., Bishop, J.D.D., Viard, F., Queirós, A.M., Merino, G., Buisman, E., Austen, M.C. (2016). Costs and benefits to European shipping of ballast-water and hull-fouling treatment: Impacts of native and non-indigenous species. *Marine Policy*, 64, 148–155.
17. Martín-Rodríguez, A.J., Babarro, J.M.F., Lahoz, F., Sansón, M., Martín, V.S., Norte, M., Fernández, J.J. (2015). From Broad-Spectrum Biocides to Quorum Sensing Disruptors and Mussel Repellents: Antifouling Profile of Alkyl Triphenylphosphonium Salts. *PLoS ONE*, 10(4), e0123652.
18. Buck, E.H. (2010). Ballast water management to combat invasive species. Congressional Research Service. 25. Available: <https://digitalcommons.unl.edu/crsdocs/25>.
19. Chris, W. (2017). Controlling the Spread of Invasive Aquatic Species with the Ballast Water Management Convention. Available: <https://waterandhealth.org/disinfect/public-health/controlling-spread-invasive-aquatic-species-ballast-water-management-convention/>.
20. Bircher, K. (2016). UV Treatment of Ballast Water: Market, Regulations, Validation Test Methods. *IUVA News*, 18(2). Available: <https://www.iuvanews.com/stories/070116/uv-treatment-ballast-water.shtml>.
21. Phillips, S. (2006). Ballast water issue paper. Available: <https://katv.pw/id579200.pdf>.

А. Холдебарин, Н. Мозаффарин, В. Вамболь, С. Вамболь, Н. Мозаффарин

ВЛИЯНИЕ СУДОВЫХ БАЛЛАСТНЫХ ВОД НА ПОЯВЛЕНИЕ ИНВАЗИВНЫХ ВИДОВ И, КАК СЛЕДСТВИЕ, НА СОСТОЯНИЕ ОКРУЖАЮЩЕЙ СРЕДЫ И ЗДОРОВЬЕ НАСЕЛЕНИЯ: КРАТКИЙ ОБЗОР

Водные пути сообщения активно используют для различных видов перевозок. И здесь очень важно обеспечить устойчивость судна на плаву для его безопасности. Для этого необходимо учитывать изменение давления воды на корпус судна, контроль глубины его погружения (осадку), а также компенсацию снижения веса в результате расходования топлива или воды, необходимость обеспечения бокового баланса и устойчивости – как факторов, влияющих на балластировку любого судна. В качестве жидкого балласта для балластировки используются балластные воды. Балластная вода содержит большое количество живых организмов различных видов, которые находятся на разных стадиях жизни (яйцо, личинки, цисты, споры или взрослые особи). Эти водные инвазивные виды наносят ущерб рыбному хозяйству, аквакультуре, системе водоснабжения, промышленной инфраструктуре, биоразнообразию и среде обитания. Цель исследования – изучить открытые источники информации и проанализировать их, чтобы определить влияние судовых балластных вод на появление инвазивных видов и, как следствие, воздействие этих видов на окружающую среду и здоровье населения. Поиск источников осуществлялся по ключевым словам «балластная вода», «экология», «окружающая среда», «общественное здоровье» и «инвазивные виды», а также по различным комбинациям этих слов с помощью Google Scholar. Ограничения в поиске источников: период с 2005 года; по релевантности. Изучены особенности одной из причин распространения инвазивных видов и экологически негативных последствий для водных систем и здоровья населения. Практическая ценность исследования заключается в том, что результаты исследования могут быть использованы для обучения работников водного транспорта и обеспечения экологической безопасности водных систем. Хищничество, паразитизм, широкое использование новых патогенных микроорганизмов, генетические изменения, изменения среды обитания, изменение вида и потеря биоразнообразия являются наиболее важными экологическими воздействиями. Экзотические виды живых организмов, которые часто доставляются с балластной водой, вызывают изменения в функционировании экосистем, изменяя круговорот питательных веществ и снижая качество воды. Установлено, что некоторые инвазивные виды, переносимые балластной водой, влияют на здоровье населения, увеличивая риск возникновения паразитизма и патогенных микроорганизмов. К ним, например, относятся *Vibrio Cholera* и *Giardia duodenalis*.

Ключевые слова: водный транспорт, балластная вода, инвазивные виды, окружающая среда, здоровье населения.