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Designing and Development of Automated Marine Sewage Treatment Plant(m-stp) using Ultraviolet Lights with Holding Tank and Shore Connection to Discharge Pipe for Domestic Vessels

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Abstract

Some domestic ships do not have a sewage treatment plant (STP). Domestic ships with STPs cannot continuously monitor the acceptable value or standards of predetermined treated waste liquid quality as set specifically in MARPOL (Marine Pollution) 73/78 Annex IV guidelines. In effect, domestic ships are susceptible to committing the maritime violation. Therefore, this study was conducted to determine the application of a Marine Sewage Treatment Plant (MSTP) among domestic ships. This MSTP used ultraviolet (UV) lights and a coliform sensor to monitor the waste liquid quality. The study was anchored in the theoretical frameworks of MARPOL (Marine Pollution) 73/78 Annex IV Regulation (Pollution Regulation for Sewage) and RA (Republic Act) 9275 (Clean Water Act). The study site was John B. Lacson Foundation Maritime University (JBLFMU)-Molo, Iloilo City, Philippines. The method of this study was a laboratory experiment using several samples from the AMSTP that will be submitted for laboratory testing. This study was initially funded by the Department of Science and Technology (DOST) in the Philippines for one year (2023-2024). The invention will be submitted for commercialization after testing the application. This study will be subjected to partnerships with international shipping companies and corporations. Maritime and ship applications of this study will be used by domestic ships and sea-crafts in treating their disposal wastes plying Iloilo-Guimaras Strait. MARINA (Maritime Administration) will use this study to make decisions about maritime policies and regulations.

Keywords: Marine Sewage Treatment Plant (MSTP), Ultraviolet Lights, Treated Waste Liquid, MARPOL 73/78 Annex IV Guidelines, and RA 9275.

Introduction

Human waste or simply sewage onboard ships generate pungent smells containing aerobic bacteria in a decomposition process. Sewage, when not properly treated well before it is discharged into sea, may consume the dissolved oxygen present in the seawater forming essential needs to sustain the life in the case of fish, crabs, corals, sea grasses, and the like. This eventually possesses a greater threat in the balance of marine ecosystem if not examined properly and not given due attention [1].

With the advent of advanced and cutting-edge technology in the field of automation in the recent years, almost everything is possible. Making use of this technology in the maritime sector makes the operation and monitoring of ships by ship operators and managers easier and more reliable. Simply put, there are technological innovations that are utilized to facilitate the accurate monitoring and control of pollutants such as sewage discharged at sea, and improvements for existing technology is expected. This could be one of the best practices to preserve the marine environment in the long run.

Furthermore, illegal sewage discharges are one of the few serious offences onboard which should be taken utmost care of. Cases like these have a detrimental effect to marine environment and ship owners are susceptible to heavy fines and sanctions if caught by the implementing body in domestic shipping.

On the whole, seafarers' incompetence and credibility are questioned relative to their behavior. It is up to them to do something to keep their prestige and honor.

Disposal of wastewater has always been an environmental issue all over the world, its disposal is a major problem and a big challenge for a whole community as mentioned in the study of Cheema & Khan (2023). Furthermore, the authors mentioned that developed countries the same problem on waste disposal because of the fact that the population has little or no access to proper sanitation system.

Cheena, A. & Khan, M. (2023). Small scale sewage treatment plants: a case study of canal view cooperative, Latto ore.

Rationale of the Study

On April 23, 2020, Maritime Industry Authority (MARINA) signed its Circular No. SR-2020-02 Series of 2020 requiring Philippine registered ships to have an adequate design facility for sewage treatment plant (STP) and holding tank in compliance with the Annex IV of MARPOL 73/78 where the country is a State Party to convention.

Presently, some domestic ships do not have a sewage treatment plant. Those that own one, however, are not capable of continuously monitoring the acceptable value or standard set out as specified in MARPOL 73/78 ANNEX IV guidelines. Therefore, this makes domestic shipping susceptible to violation.

Also, old disinfection processes may not be very effective in disinfecting aerobic bacteria. A classic methodology of using chlorine tablets in large amounts leads to a violation of MARPOL Annex III or the "Regulation for the Prevention of Harmful Liquid Substance in Bulk" as this contains chemical properties in the composition of chlorine tables [2].

The ultraviolet (UV) process has highly effective process for the removal of acteria and disinfection (Soo Oh, Park, Lee, & Kang, 2003)

Domestic wastewater residue or sewage sludge waste must be properly managed, generated sewage can be used as organic fertilizer for agricultural applications however, quality of sludge must be tested before it can be used before of its effects on the both plants and animals (Sackey, Koomson, Kumi, Hayford, & Kayoung, 2023).

Sackey, N., Koomson, J., Kumi, R., Hayford, A., & Kayoung, P. (2023). Assessing the quality of sewage sludge:case study of the Kumasi Wastewater Treatment Plant. https: //. doi.org/10.1016/j. heliyon. 2023.

Theoretical Framework

A sewage treatment plant onboard ship is not just a piece of equipment. It plays a paramount role in preserving our marine environment as a whole. Thus, the effluent sewage water being discharged into the sea after passing through a series of processes must be ensured that the correct level of fecal coliform discharge must be correct and continuously monitored.

IMO, through Marine Environmental Protection Committee Resolution No. 159 (55) adopted on October 3 2006, suggests that the fecal coliform count must not exceed more than 100 most probable number (mpn)/100ml of affluent after treatment. MEPC Resolution No. 159 (55) was the updated guideline based from the old MEPC Resolution No. 2 (6) as adopted in December 1976 guideline suggested that the fecal coliform count must not exceed more than 100 most probable (mpn)/100ml of affluent after treatment.

MARINA Memorandum Circular No. SR-2020-02 entitled: "Rules and Regulation on the Construction of the Tank and Installation of Equipment to Collect, Store and Treat Sewage from Ships in Compliance to Annex IV of MARPOL 73/78 as Amended" refers to all Philippine-Registered ships owner/operator charterer/managers. Based on this context, it is clearly seen that due to the complexities of shipping operation of both domestic and international shipping, marine environment becomes polluted over the decades because of sewage dumping. As a consequence, life below water is greatly affected in relevance to the safety of marine animals for human consumption. Therefore, it is essential to take intelligent steps and responsible actions to preserve our marine environment before it is too late.

As mentioned by Pasaribu, Yamato, & Damoyanto (2023) that marine regulation was promulgated to regulate pollution of marine environment by ships as contained in Annex IV of MARPOL. this means that prevention of contamination by sewage by ships can be overcome by using auxilliary treatment plant by utilizing aerobic bacteria as waste decomposers and UV light as sterilizer or nuetralizer of waste that are harmful to the environment.

Pasribu, C., Yamado, M., & Damoyanto, P. (2023). Case study of decreasing of quality of processed waste at sewage treatment plant to contain waste disposal on Ship M/V Ck Angie. International Journal of Advanced Multidisciplinary, vol. 2, No.2. DOI; https://doi. org/10. 38035/ijam.v.2i

Objectives

General

To design and develop an Automated Marine Sewage Treatment Plant (MSTP) Using Ultraviolet Lights with Holding Tank and Shore Connection to Discharge Pipe for Domestic Vessels

Specific Objectives

1. Design an improved Automated Marine Sewage Treatment Plant (AMSTP)
2. Develop & construct AMSTP
3. Develop data acquisition system
4. Evaluation, testing, & modification – pilot testing effectiveness – in house assessment
5. Create an effective sewage treatment plant design that can be used by MARINA for standardization of the sewage treatment plant processes onboard.

Review of Literature

The intensively increase in water transport has pointed to the need to address the problem of wastewater from ships (Sonja Ketin & Marko Andrejić, 2021). The International Law on the Prevention of Marine Pollution by Sewage from Ships (MARPOL Annex IV) was presented which defines the legal obligations for the prevention of wastewater from ships [3].

Volkan Sahin & Nurten Vardar, (2020) state that wastewater formed on ships is divided into blackwater and graywater. While blackwater refers to wastewater from toilets, graywater defines wastewater from sinks, laundry and restaurants in large passenger vessels. Even though some treatments are applied onboard before discharge, wastewater contains significant amounts of fecal bacteria in excess of water quality standards.

Ultraviolet disinfection as an alternative to chlorination has since been questioned because chlorine residuals have been found to be toxic to an aquatic life (Barry G. Oliver and John H. Carey, 1976).

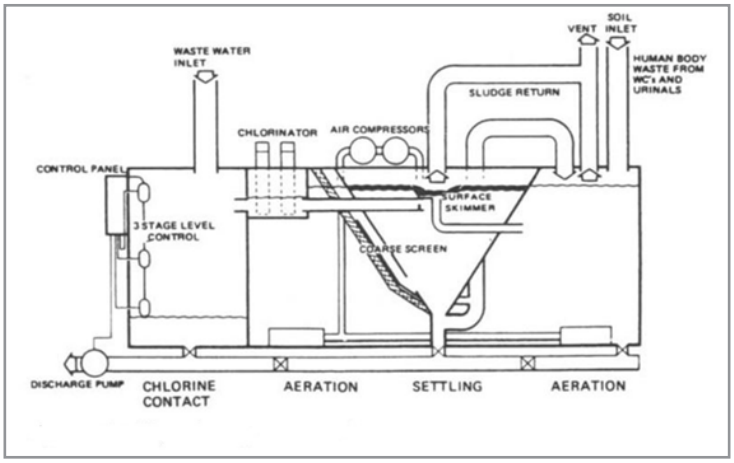
Effluents from several wastewater treatment facilities were pumped at various flow of 5 to 90 L/min through an ultraviolet treatment system designed to minimize problems associated with variable ultraviolet penetration and the concentration of indicator bacteria monitored. A 99 percent removal of coliform, fecal coliform, and fecal streptococcus could be affected with ultraviolet (Wiley, 1976).

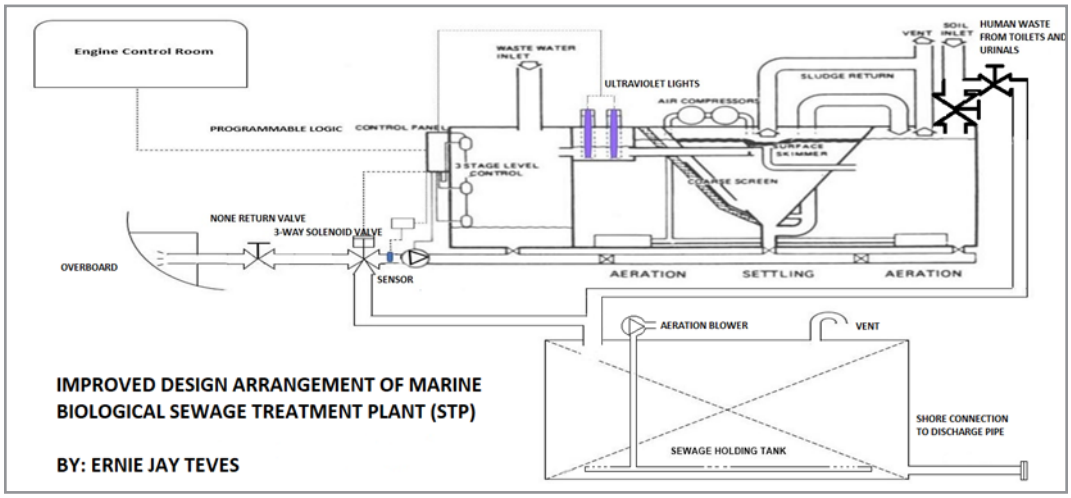
In this respect, there is a need to further give a means to innovate by incorporating the ultraviolet treatment system with a coliform sensor capable of continuously monitoring the coliform level in the treated sewage discharge within the output of the process. When the sewage discharge coliform level reaches the maximum allowable standard, it must be contained in a separate sewage holding tank through the use of three-way solenoid valve. Thus, this will not completely allow any discharges of sewage at sea.

Methodology

System Design and Planning – the first step is the data gathering and verification. This involves consultation with people in the maritime industry with regards to the standard requirements and the effectiveness of the existing sewage treatment plant in the domestic vessel corresponding to the MARPOL Annex IV. The revised standard used in the sewage discharge process and research for current issues concerning the impact of sewage pollution into the sea towards developing effective means of monitoring and treatment of sewage discharges.

System Development- after the system design and planning were established the proponent will commence system development of prototype sewage treatment plant, coliform sensor, new sterilization processes and holding tank design. The purpose of second step is to prevent the direct discharge of sewage whenever the fecal coliform level reaches its acceptable level. Also, it would be capable of holding the sewage volume equivalent to the total capacity of crew on onboard as well as to develop the exact algorithm of program control for the sewage treatment plant.





Potential Impacts (2Is)

Discuss SDGs

- Social Impact- refers to the effect or influence of the project to the reinforcement of social ties and building of local communities.
- Economic Impact- refers to the effect or influence of the project to the commercialization of its products and services, improvement of the competitiveness of the private sector, and local, regional, and national economic development.
- Modernization of domestic and merchant vessels MARPOL Equipment in mitigating the impact of sewage pollution from ships.
- Preservation of marine environment and the life below water
- Clean ocean, clean coastal waters and clean source of foods

References

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3. Oliver, B. G., & Carey, J. H. (1976). Ultraviolet disinfection: An alternative to chlorination.