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LABORATORY ANALYSIS OF SOME PARAMETERS OF WASTEWATER FROM SHIPS DOCKED AT APAPA SEAPORT, LAGOS, NIGERIA

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ABSTRACT

This study empirically investigated laboratory analysis of some parameters of wastewater from ships docked at Apapa seaport. The researchers adopted an experimental research design, conducting laboratory analyses of samples from ships' wastewater to determine the levels of certain parameters that could contribute to marine pollution in the port environment. The samples were collected from randomly selected ships at berths in Apapa seaport locations. The results of the analysis shows that the level of some parameters when compared to the DPR standard or limit based on physico-chemical and microbiological parameters of ship generated wastewater from vessels are significant and that oil and grease content of bilge water, ship ballast water and garbage waste from Apapa port could significantly impact on Nigeria marine environment. The study therefore recommended the adoption of an integrated model for marine pollution administration in port environments by the port authority, and medium- and long-term strategies and guidelines in place to achieve continuous reduction in permissible discharges until zero discharge is achieved.

Keywords: Ship Wastes; Laboratory Analysis, Bilge Water, Ballast Water, Marine

1. INTRODUCTION

Wastewater onboard can be divided into “black water” sewage containing feces and “graywater” wastewater from washing of living quarters, Oily Bilge water mixture of water, oily fluids, lubricants, cleaning fluids and other similar wastes that accumulate the lowest part of vessel from a variety of different sources including engines and piping and ballast water. In most maritime nations, ships are not allowed to discharge untreated black water within 12 nautical miles offshore according to the International Convention for the Prevention of Pollution from Ships (MARPOL). Moreover, port authorities have to deal with two different groups of regulations for wastewater treatment: with legal requirements for effluent from wastewater treatment plants based on land and legal requirements for effluent from vessels (e.g. from Waste Water Treatment Plant onboard), which are stricter than the requirements for wastewater treatment on land (Szepes, 2013).

The study proposes the analysis of ship-generated wastewater as a proxy for the analysis of water quality in the berthing area exposed to pollution from ship sources. A major assumption of this study therefore, is that the analysis of the properties of wastewater collected at the source (ships at berth) provides a proxy medium for understanding the nature and extent of pollution in the port environment and the volume of wastes collected over the years.

Marine pollution is classed as point source or non-point source. Point source pollution occurs when there is a single, identifiable, and localized source of the pollution. That is, point source “means any discernible, confined is discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation or vessel or other floating craft from which pollutants are or may be discharged. An example is directly discharging sewage (i.e. water-carried waste, in solution or

suspension, which is intended to be removed from a community, also known as wastewater) and industrial waste into the ocean, Bamanga, Fones, and Mills (2014). Non-point source pollution occurs when the pollution comes from ill-defined and diffuse sources. It arises from a broad group of human activities for which the pollution has no obvious point of entry into receiving water courses. Non-point source pollution is much more difficult to measure, identify and control than point sources. These include return flows from irrigated agriculture, urban runoff (from roofs, streets, parking lots, etc.), transportation (roads, railways, pipelines, hydro-electric corridors).

Against the backdrop of public concern and the need for mitigating policies, the shipping industry has actively sought to curtail the negative environmental effects arising from the shipping sector. At an international level, various legal instruments and controls have been provided to encourage regulation and enforcement by the flag state, coastal states and port state control. For example, the International Maritime Organization (IMO) convention on marine pollution MAPOL 73/78 outlines measures aimed at completely eliminating the willful and intentional discharge into the seas of oil and noxious or hazardous substances- chemicals, packaging, sewage and garbage.

Extant studies indicate the impact of ship-source pollution on the coastal environment in and outside Nigeria. Specifically, Carpenter and McGill (2003) examined portside reception facilities in ports in the North Sea. Also, Gokce, Cicek & Ceyhun, (2014) investigated the effects of shipping accidents on the marine environment and the coastal region in the Turkish Seas have also been examined in Özdemir, Yılmaz & Başar (2015).

Nigeria's coastal environment has experienced a significant increase in the number of ships calling at the ports over the past few years. This increase in vessel traffic has led to a major rise in the volume and types of ship-generated waste, which needs to be processed by port reception facilities.

The increase in maritime traffic calling at Nigeria's ports is of great significance. According to the annual statistical report of the Nigerian Port Authority (NPA), there has been an approximately 16 percent increase in the number of ships which call at the port of Tin Can and Apapa port between 2010 and 2018.

Ship-generated waste is expected to grow significantly in the coming decade within our nation's ports; therefore, it is imperative to improve the capabilities of their port reception facilities. The round clock problem of environmental pollution and degradation, especially of the Nigerian marine environment, occasioned by oil spills, exploitation and lifting, gas flaring and introduction of noxious and harmful substances into the marine environment like ballast water has over the years destroyed aquatic life, vegetation and the ecosystem.

Salt water, together with sanitary water, goes to a biological wastewater treatment plant situated at the end of the sewage system, where salt destroys bacteria (biomass) needed for the process of purification. Sodium Chloride (NaCl) hurts the purification process and can cause a delay in the treatment when concentration is greater than 10 percent (Bamanga, Amaeze and Al-Anzi, 2019).

2. Materials and methods

In this study, the laboratory research design was employed. This design has to do with conducting a laboratory test. Waste samples were collected from vessels berthed at different locations. The samples were: black waste, bilge water and ship ballast water. These samples were collected with sterile 75 cm screwed top plastic bottles; they were stored in a temperature of 4°C. In order to

avoid the staleness of samples, some of the pollution indicator parameters were determined within six hours of sample collection.

Laboratory analysis

The analysis covered physical, chemical and microbiological parameters of the water samples. The parameters tested for were: pH, temperature, conductivity, total dissolved solids, total suspended solids, turbidity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total oil and grease, copper, iron, lead, zinc, aluminium, cadmium, mercury, total coliform count, total heterotrophic bacteria, and total heterotrophic fungi.

Data collection utilized a sampling method whereby water samples from marine cargo vessels at berths were subjected to physico-chemical and microbiological analysis according to the American Public Health Association (APHA) method to determine the level of concentration of identified parameters. Standard procedures were applied to prepare our sample for the analysis. Thus, for the sake of brevity, we have in this section omitted the laboratory procedures which followed. These are attached in the Appendix. In the following sections, we discuss the results from the analysis of our samples. Significant values of parameters obtained from the laboratory analysis are compared to the Department of Petroleum Resources (DPR) specified standards for effluent discharges from barges to guard against: hazards to human health, harm to living organisms (fauna and flora) and aquatic life and impairment of quality of adjacent land, surface and ground waters (Encheva, (2015).

The water samples were analyzed using physico-chemical and microbiological analysis according to the American Public Health Association (APHA) method to determine the level of concentration

of identified parameters. Standard procedures were applied to prepare our sample for the analysis. Significant values of parameters obtained from the laboratory analysis were compared to the International Maritime Organization (IMO) specified standards for effluent discharges from barges, ships and tankers working in inland or near-shore waters. The IMO standards which place limits on quantity and quality of effluent discharges from vessels to guard against hazards to human health, harm to living organisms (fauna and flora) and aquatic life and impairment of quality of adjacent land, surface and ground waters, were appropriately complied with (Encheva, (2015).

3. Results and discussion

The results of the laboratory analysis are presented in the table below.

Table .1: Comparison of the parameters from Bilge water, Ballast water and Black water with the Department of Petroleum Resources (DPR) Nigeria, Specified Limits

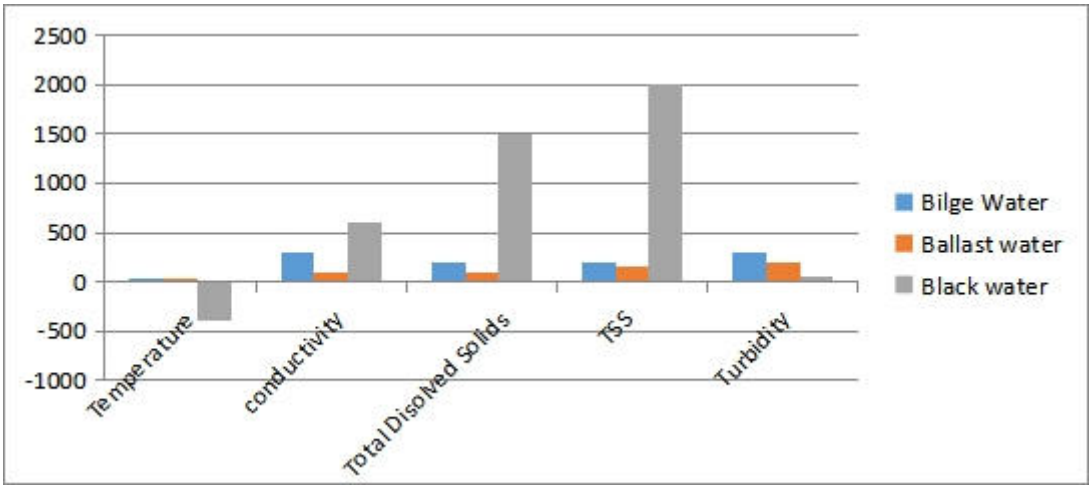
Parameters	**Unit**	**Bilge Water**	**Ballast water**	**Black waste**	**Mean**	**SD**	**DPR * Std.**	**Significant (Mean * > DPR Limit)**
Date sampled		9/07/24	24/07/24	24/07/24				
pH	-	6.25	6.73	7.4	6.78	0.28	6.5–8.5	NO
Temperature	OC	29.50	29.75	29.75	29.75	0.36	30	NO
Conductivity	µS/cm	356.0	150.0	490	350	3.40	100	YES
Turbidity	mg/L	256.0	160.0	21.00	145.8	1.58	10	YES
TDS	mg/L	190	129	1499	606.1	5.78	<2000	NO
TSS	mg/L	200	139.2	1999.9	779.4	21.5	50	YES
COD	Mg/L	121	68	5.4	65.1	40.60	40	YES
OIL/Grease	µg/L	72.0	20.1	15.90	35.67	12.5	48	NO
DO	Mg/L	2.01	2.4	3.40	2.625	0.28	5.0	N0
BOD	Mg/L	48	30	13	30.2	7.29	30	YES
Lead	µg/L	0.444	0.12	0.00	0.503	0.101	0.05	YES
Cadmium	µg/L	0.113	0.09	0.25	0.151	0.05	0.003	YES
Iron	µg/L	3.98	1.72	2.02	2.57	40.71	0.3	YES
Copper	µg/L	1.54	0.75	1.291	1.17	0.21	1.5	NO
Chromium	µg/L	0.005	0.006	0.007	0.006	0.001	0.005	NO
Mercury	µg/L	nil	nil	nil	nil	nil	0.1	NO
Zinc	µg/L	2.00	0.81	0.04	1.01	0.40.7	1.0	NO

Source: Results of the experiment based on fieldwork 2023 * Extracts from DPR.

In Table 1, we present the descriptive statistics of the physico-chemical and microbiological parameters of the sample investigated. Figures 1-4 display the variability in values of parameters given the different types of wastewaters: bilge, ballast and black water. Except for the trace metals, there was much variability in the parameter values of the physical, chemical and microbiological properties of the samples. This observation can be inferred from the error bars shown in the figures

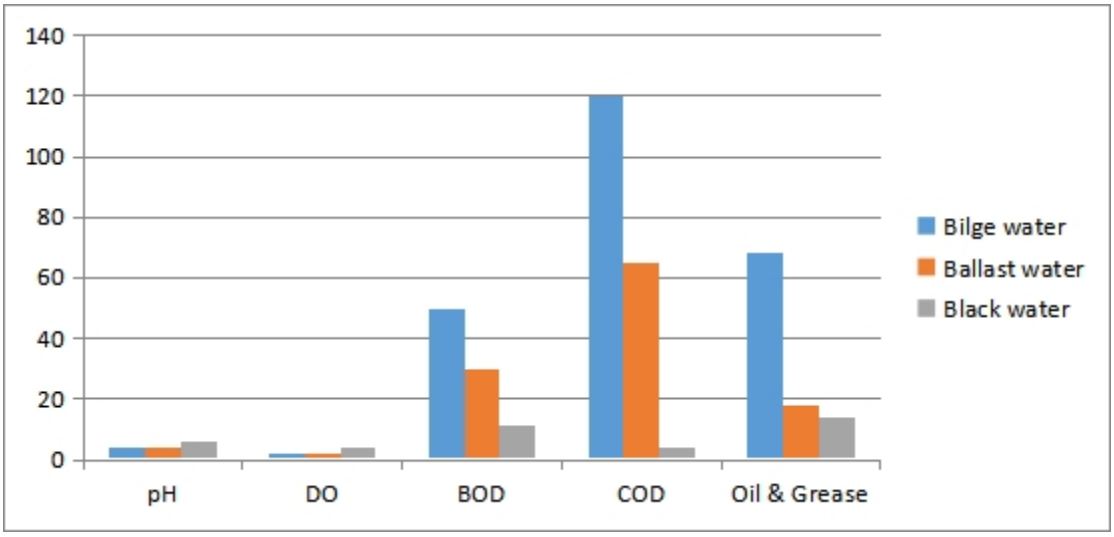
for the various samples of wastewater analysed. This variability is negligible and does not indicate the presence of outliers, which could affect our conclusions

Figure .1. Distribution of the physical parameters of ship wastewater



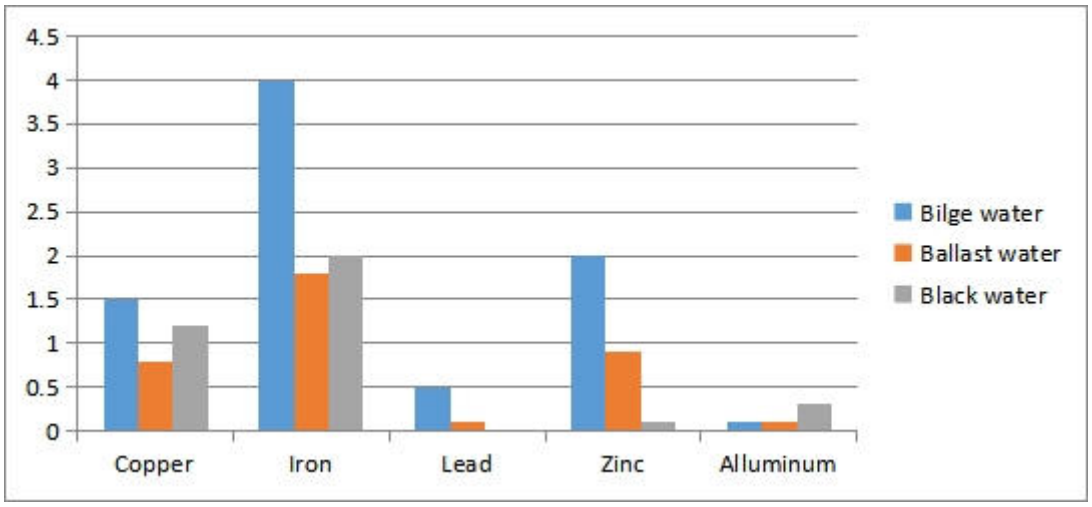
Source: Nwagu, Anyanwu, Ejem, Nwosu And Nwagu (2024)

Figure 4. 2. Distribution of the chemical parameters of ship wastewater.



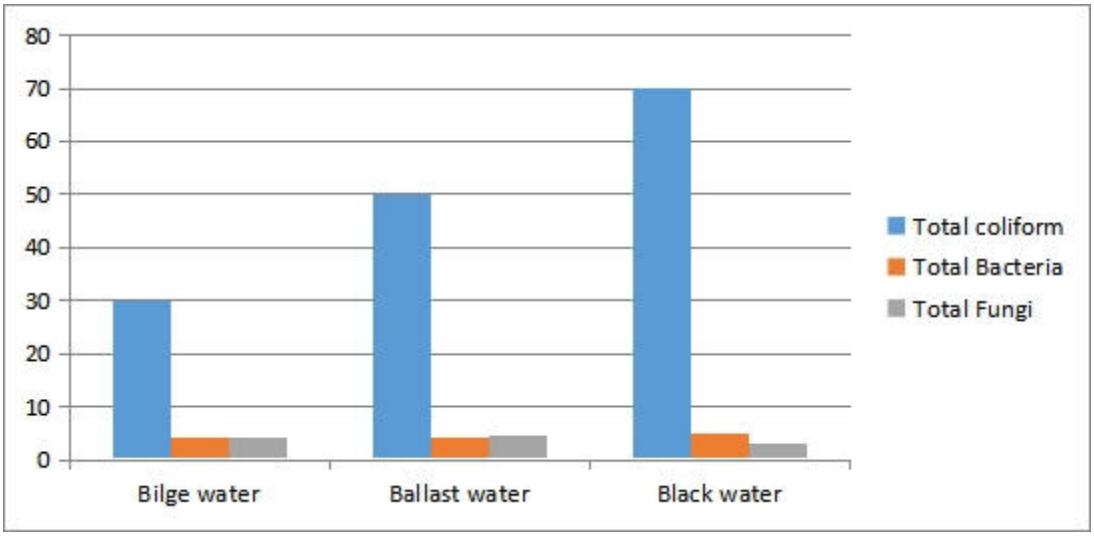
Source: Nwagu, Anyanwu, Ejem, Nwosu And Nwagu (2024)

Figure 3: Distribution of the trace metal parameters of ship wastewater



Nwagu, Anyanwu, Ejem, Nwosu And Nwagu (2024)

Figure 4. Distribution of the microbiological parameters of ship wastewater



SOURCE: Nwagu, Anyanwu, Ejem, Nwosu And Blessing (2024)

Interpretation of results

pH is an indicator of acidic or alkaline conditions of the water status. The observed value of pH (6.72), indicates that the ship wastewater sample is slightly acidic. The pH increased significantly with different types of ship wastewater and falls below the DPR permissible range. As the acidity of the surface water increases, submerged aquatic plants decrease depriving water fowl of their basic food source. Caustic soda from soaps and detergents from washed materials on board vessels may have been the cause of the increase in pH observed in different samples in this study.

Temperature (27.7) increased significantly over different samples. The range falls within the DPR standards. The temperature difference in any aquatic habitat is affected by weather, and the extent of shade from direct exposure to sunlight. Also, biodegradation of organic matter that enters the water may increase heat conductivity values recorded in Total Hydrocarbon Content, THC (13.00-17.31mg/l), turbidity (10.70-11.00mg/l), total suspended solids, TSS (779ug/l), and temperature (27ºC), all fall within the DPR allowable limits and therefore do not constitute any treat to the recipient marine environment. This was also the case of the chemical oxygen demand, COD (65ug/l), biochemical oxygen demand, BOD (30ug/l), and heavy metals of lead, iron, copper, chromium, and zinc.

Oil and Grease were determined according to the API-RP45 method using a Spectrophotometer. The sample was extracted twice with a 1:10 ratio of Xylene to sample using a separator funnel. The combined extract after centrifuging was read in the spectrophotometer using Xylene as the reference material at 400nm wavelength. Readings obtained from the spectrophotometer were traced out on the calibration graph and used to calculate the concentration of oil and grease in mg/L in the sample.

Conductivity values recorded in this study (336 S/cm) are found to be above the DPR standards. The black wastewater sample recorded the highest value of 500S/cm of conductivity. The increase may be attributed to high levels of dissolved solids in the sample, such as chloride, phosphate and nitrate. It may also be a result of the storage of the waste product onboard vessels. TDS increased significantly with different samples of ship wastewater, with a mean of 606.4 mg/L, which is below the DPR permissible limit for discharges in inland or near-shore water. The observed high TSS in black wastewater could be attributed to the influx of non-biodegradable solids in the sample.

Turbidity is associated with suspended solid concentrations; the turbidity range values recorded in this analysis were low in black wastewater and highest in bilge wastewater with a range of (160, 145.8) NTU, which falls above the DPR permissible limit. The high turbidity recorded in bilge water can be attributed to leaks from the machinery equipment of the vessel as stated before in this study

Dissolved oxygen (DO) is a measure of the degree of pollution by organic matter, the destruction of organic substances, as well as the self-purification capacity of the water body. The DO of ship wastewater (2.63 mg/L) was lower than the DPR acceptable limit of 5.0 mg/L. DO in liquid provides a source of oxygen needed for the oxidation of organic matter when the concentration is high, and a lack of it causes the water to become dead or void of aquatic life.

The mean value (30.2mg/L) of BOD in ship wastewater was slightly above the DPR acceptable limit of 30 mg/L, which means that discharging wastewater into the marine environment will affect the aquatic life and the ecosystem. The chemical oxygen demand (COD) recorded in this study (26.7 mg/L) was above the DPR standard of 40 mg/L. Observed Iron (Fe) values ranged from

1.72–3.98 (2.57mg/L) and were found to be above the DPR permissible limit of 0.30 mg/L. Iron values increased significantly with different samples of waste and were highest in bilge water.

Copper (1.17 mg/l) was below the DPR permissible limit of 1.5 mg/L. Higher concentrations of bacteria in the sea are strongly linked to total coliform and faecal coliform levels. A high microbial population in an aquatic system reflects the input of microorganisms from ship wastewater discharged into the marine environment, along with the availability of growth-supporting organic matter. Elevated bacterial counts indicate the level of water pollution, as they signal the amount of organic matter present.

From the result of the experiment, the value of oil and grease content of bilge water (72µg/L > 48µg/L of DPR criteria), hence the research concluded that the Oil and grease content of bilge water significantly impacts Nigeria's coastal environment.

However, the mean value of oil and grease contents of the three sample is not significant or below the recommended DPR limit, that is to say that oil and grease content in bilge water was 72ug/l which is more than 50percent of the allowable limit of DPR, even though there was a record of considerable reduction below the allowable limit of DPR for black waste and ballast water.

Ship ballast water does not significantly impact Nigeria's coastal environment.

The findings from the laboratory analysis of the ship's ballast water sample based on the DPR criteria for water quality show that most of the parameters exceeded the allowable limit of DPR. These include, the conductivity (150 µS/cm > 100 µS/cm), turbidity (160.0 mg/L> 10 mg/L), Total Dissolved Solids, TSS (139.2 mg/L > 50 mg/L), lead,(0.12 µg/L > 0.05 µg/L), Cadmium(0.09 µg/L > 0.003 µg/L), Iron,(1.72µg/L > 0.3µg/L) and Chromium,(0.006 µg/L> 0.005µg/L).

However, the above-mentioned parameters that exceeded the allowable DPR limit impact on the coastal environment. Hence, the researcher concludes that Ship ballast water does significantly impact on Nigeria's coastal environment.

Recommendation

i. Marine pollution management and administrative frameworks in Nigerian ports and should incorporate elements of the scientific process. Given the multiplicity of organisations involved (i.e., the port authority and other agencies whose interests may potentially undermine results)

ii. The government, through the ports authority, should adopt an integrated model for marine pollution administration in port environments.

iii. To reduce toxicity in the system, there should be medium- and long-term strategies and guidelines in place to achieve continuous reduction in permissible discharges until zero discharge is achieved.

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