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Evaluating Ballast Water Quality at Forcados Terminal, Southern Delta, Nigeria

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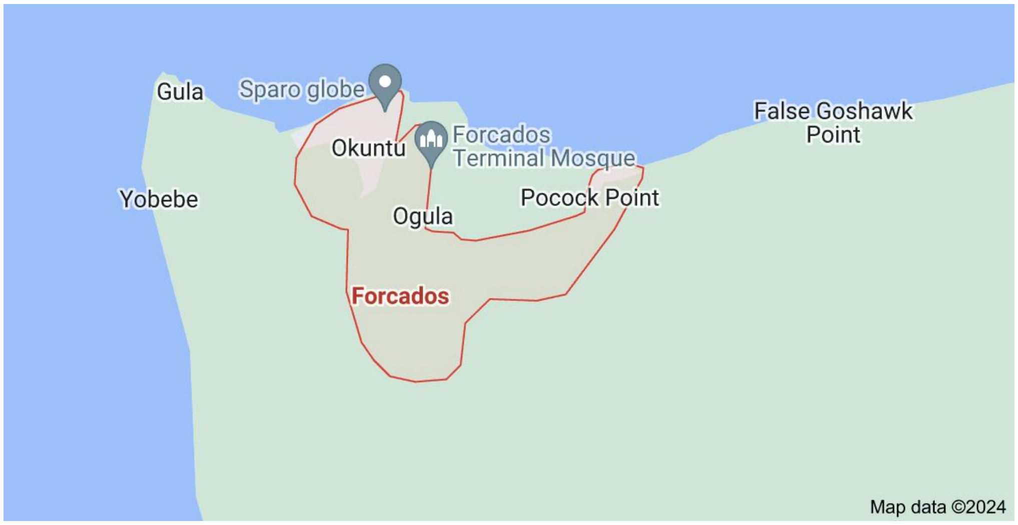
Abstract
Forcados river terminal is deteriorated by anthropogenic and congenital exercises. The aim of this preliminary study is to assess ballast water through some pollution parameters as pH, electrical conductivity (EC), dissolved oxygen (DO), total alkalinity (TA), chlorine (Cl), nitrates (N), phosphate (P), turbidity (TB), lead (Pb), zinc (Zn), total dissolved solids (TDS), chromium (Cr), bacteria count (BC) and polynuclear aromatic hydrocarbons (PAHs). Maritime transport plays a major role due to its cost effectiveness and reliability. Ship-based marine pollution has a serious level for the environment, its biodiversity and economy. Results from the analysis showed that some parameters of ballast water from ships in Forcados (Chloride: 3.40-5.15 mg/l, phosphorus: 2.42-4.42 mg/l, turbidity: 18.70-23.51 mg/l, total dissolved solids: 270.31-341.21 mg/l) are not suitable for aquatic fauna. Hence, some special appraisal is needed. International Maritime Organization (IMO) regulations should be reviewed related to ballast water and local authorities should be educated on them before it is discharged into the river.

Keywords: Ballast water, Forcados, Ecosystem, Pollution, International Maritime Organization.

Introduction

Pollution of water from domestic, agricultural and industrial activities threaten living species and elevates deterioration of the balance in ecological system (Ruqayah et al., 2023). Ballast water poses threat to the marine ecosystem. Within vessels or ships, it is used to maintain stability in loading and unloading activities but it also provides carrier for the transport of non-indigenous species and pollutants from one port to another. Deballasting water from the ballast tank into the river after treatment, that is if treated, leads to pollution (Chen et al., 2022) which causes change in biodiversity in coastal water, disrupting environmental, economic and human health. The protection of marine and coastal regions is an important modern ecological issue (Wan, et al., 2021). With increase in intercountry and intercontinental transport been cheaper, its pollution constitutes about 30% (Gerhard et al., 2019). Activities associated with water (marine) transportation include but are not limited to oily water, sewage, dirty water from washing of tanks and domestic waste.

The practice of using ballast water in maintaining safe operation throughout voyage eases tress on the engine hull, provides balance and improves maneuverability, weight loss due to shortage of fuel and water (Lv et al., 2021). In other to control the problem of discharge of an alien organism from one place to another, which becomes dominant causing economic and ecological disruption, international convention for the control and management of ship ballast water and sediments was adopted which provides standard for ballast water exchange and treatment as required by IMO (2004). It involves chemical, physico-chemical inactivation (disinfection and deoxygenation) by displacement of dissolved oxygen. Apart from the invasive non-native species which are threats to fish eggs, larvae and zooplankton, leading to losses in marketable fish species industries, they can increase taste and odour in consuming the water, impede boat performances, increase algae growth which leads to eutrophication and engine damage (Ebin & Abua,2019). In additional to the translocation of microorganisms, there is the inlet of inorganic and organic matter present in water and sediments which is a decisive factor in the spread of pollution and ecological balance damage (Lv et al., 2021). Rheological, chemical, climatic and seasonal conditions influence the quality of river water. These parameters are pH, electrical conductivity, total hardness, chlorides, nitrates, phosphates, turbidity, total dissolved solids, polyaromatic



hydrocarbons, heavy metals and marine species (Shang et al., 2021). This study presented the analysis on ballast water of Forcados Terminal, Southern Delta, Nigeria to assess its quality based on some pollution parameters.

Materials and Methods

Study Area

Figure 1: Map of Forcados

Forcados lies between latitudes 5^0 21'and $5^0$35'Nand longitudes 5^0 31' –5^0 51'E. It is an estuary convergence of Forcados and Warri tributaries. It spans about 4km into the Atlantic Ocean in the South. It is a major navigable channel of the Niger Delta. It starts from Aboh and flows through zones of freshwater swamps and coastal sand ridges before completing its 198 km course to the Bight of Benin. It is located in Burutu Local Government Area of Delta State, with harbours and ports created during the colonial era (Ogidiaka & Ikomi, 2021). Majority of the populace are predominantly fishermen and transporters along the course of the river. It has rainy seasons from April to November and dry season from November to March. The map of Forcados is shown in Figure 1.

Determination of Water Parameters

pH was measured on site by a pH meter, while electrical conductivity was measured using EQ – 550 conductivity meter. Dissolved oxygen was estimated using Winkler's methods, total alkalinity by titration method, and colorimetric titration with EDTA was used to measure total hardness. Chloride was determined with conductivity meter for dual function of chloride and salinity. Phosphate was measured using colorimetric methods with UV-visible spectral–10, total dissolved solids was determined with a TDSmeterTH-TDS15. Heavy metals (lead, zinc and chromium) was determined by standard methods (APHA, 2017), total bacteria count was determined using the method described by Ademoroti (1996) and total petroleum hydrocarbons was measured with gas chromatography Agilent 6890series4.

Water samples from ballast water were obtained from five (5) different ships between 20 and 40cm above and below the surface for a period of six (6) weeks to account for variation, in 10litre containers. Then pH and dissolved oxygen were determined immediately (on site). It was refrigerated and transferred at $4^{\circ}C$ until further analysis according to APHA (2017). The methods for PAH determination followed methods described by Ekere et al. (2019) and Grmasha, et al. (2023). About 10 cm^3 of ballast water sample was homogenized with Na_2SO_4 until a homogenous mixture was obtained. It was transferred to a Soxhlet extractor with 100 cm^3 of hexane and dichloromethane 1:1 for 15hrs. The extract was evaporated to 2 cm^3 using a rotator and purified by solid extraction with 2g of aluminum oxide (5%deactivated upper part) and 2g of silica gel (5% deactivated lower part). The PAHs were eluted with 10ml of hexane, 5ml of hexane + dichloromethane (9:1) and 10 ml of hexane + dichloroethane (4:1). Eluted fractions were combined and evaporated to 1 ml. This was used to determine PAHs in gas chromatography equipped with HPS

(Agilent 6890 series 4, Agilent Avundable, USA) crossed linked with siloxane with 0.2m x 3.0m and flame ionization detector (FID) with helium gas as carrier of initial temperature of 100°C and finally raised to 310°C at a rate of 4°C/min.

Results

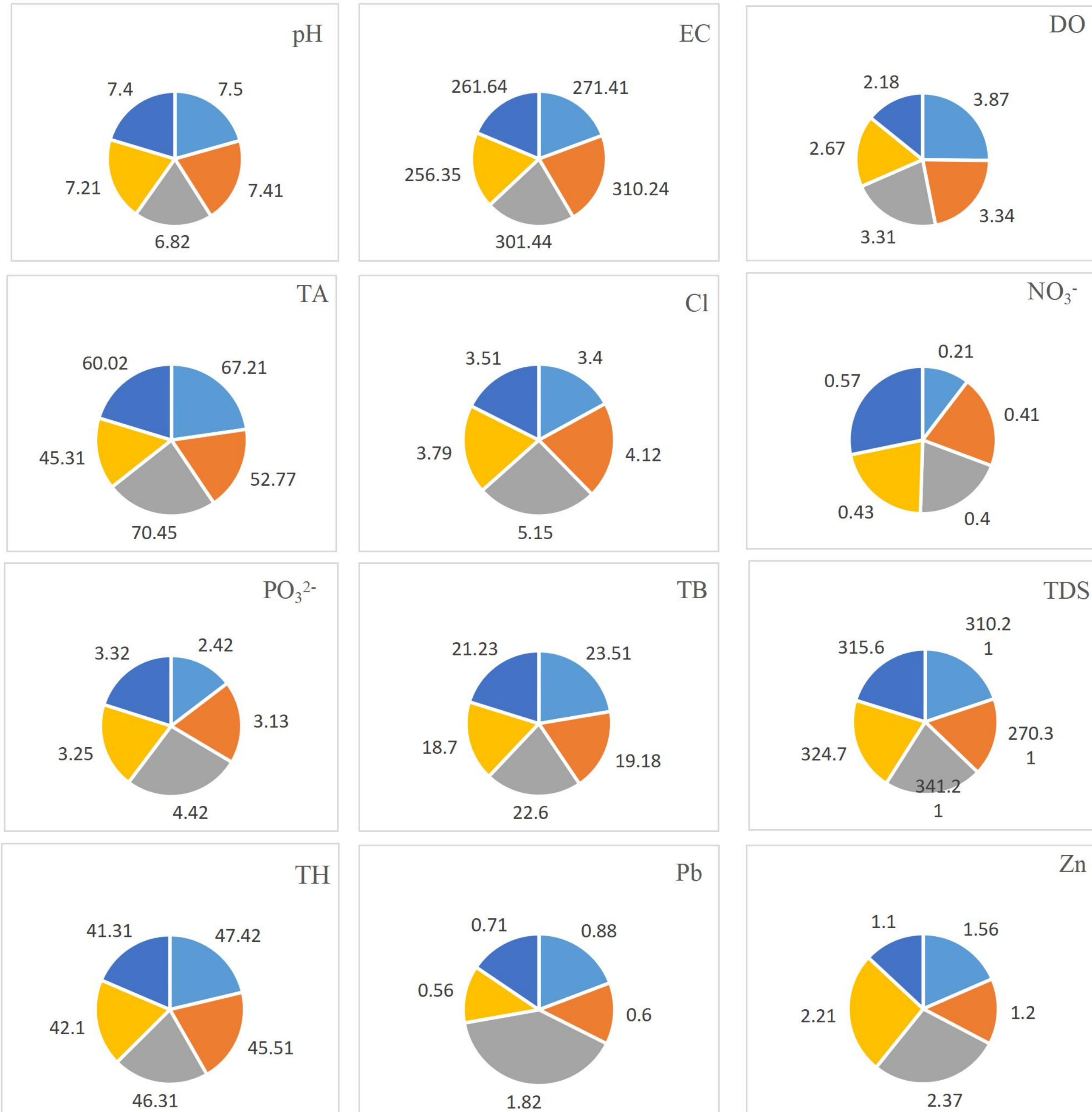
The various parameters associated with ballast water pollution are presented in Table 1.

Table1: Experimental data of pollution physicochemical/bacterial count.

6 Parameter	S1	S2	S3	S4	S5
pH	7.50	7.41	6.82	7.21	7.40
EC (Ʊs/cm^3)	271.41	310.24	301.44	256.35	261.64
DO(mg/l)	3.87	3.34	3.31	2.67	2.18
TA (mg/l)	67.21	52.77	70.45	45.31	60.02
Cl(mg/l)	3.40	4.12	5.15	3.79	3.51
NO_3^-(mg/l)	0.21	0.41	0.40	0.43	0.57
PO_3^{2-}(mg/l)	2.42	3.13	4.42	3.25	3.23
TB(mg/l)	23.51	19.81	22.60	18.70	21.23
TDS(mg/l)	310.21	270.31	341.21	324.70	315.60
TH(mg/l)	47.42	45.51	46.31	42.10	41.31
Pb(mg/l)	0.88	0.60	1.82	0.56	0.71
Zn(mg/l)	1.56	1.20	2.37	2.21	1.10
Cr(mg/l)	0.46	0.21	1.73	0.89	0.91
Bacteria count (cfu)	4.2x10^6	2.1x10^6	2.9x10^6	1.9x10^6	1.5x10^6

EC=[2]electrical conductivity, DO=dissolved oxygen, TA=total alkalinity, TH= total hardness, Cl=chloride, NO_3^-=nitrates,PO_3^{2-}=phosphorus, TB=Turbidity, TDS=total dissolved solids, BC = bacteria count.

pH is crucial for the survival of aquatic lives. It is between 6.87 – 7.50. It has been observed that pH between 6.5–9.0 is useful for most aquatic lives and food for microbial growths in rivers. It determines the productivity in water bodies (Salahuddin, 2023[a,b]).The electrical conductivity in ballast water is considered good for hydroponics and encourage for growth of aquatic lives. It ranges from 256.35–310.24 u^s/1cm. Dissolved oxygen was between 2.18-4.34 mg/l, dissolved oxygen of 5 mg/l and above is considered good for water. From this study, total alkalinity of 20 mg/l and above is good for good water that can sustain aquatic lives. Total hardness was good since it is between 41.31–47.42 mg/l. The chloride amount in this was low, which is not suitable for most aquatic organisms. Nitrate levels above 0.75 mg/l causes stress to aquatic lives and above 5 mg/l is considered toxic. Phosphorous levels in ballast water, when released into the river can cause eutrophication, therefore it should be reduced. Turbidity level is good for intensive culture system but for fish production. It was about 30-80 mg/l while total dissolved solids amount of less than 400mg/l is not harmful for fish production. Some suitable measure is required so that its level is increased. This study recorded 270.31–341.21 mg/l. These parameters are recorded graphically in Figure 2.


pH
7.4
7.5
7.21
7.41
6.82
EC
261.64
271.41
256.35
310.24
301.44
DO
2.18
3.87
2.67
3.34
3.31
TA
60.02
67.21
45.31
52.77
70.45
Cl
3.51
3.4
3.79
4.12
5.15
NO_3^-
0.21
0.57
0.41
0.43
0.4
PO_3^{2-}
3.32
2.42
3.13
3.25
4.42
TB
21.23
23.51
18.7
19.18
22.6
TDS
310.2
1
315.6
270.3
1
324.7
341.2
1
TH
41.31
47.42
42.1
45.51
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Pb
0.71
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Zn
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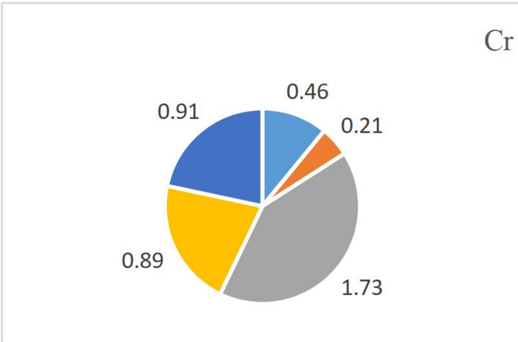


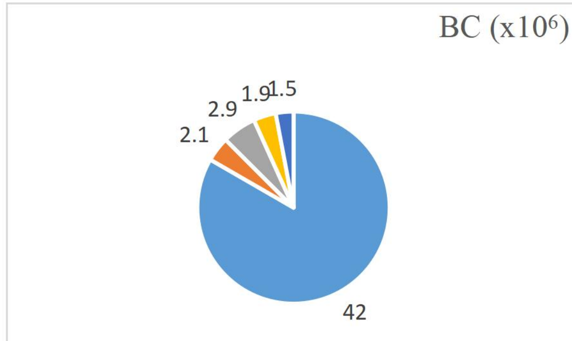


Figure 2: Graphical representation of results from analyzed parameters.

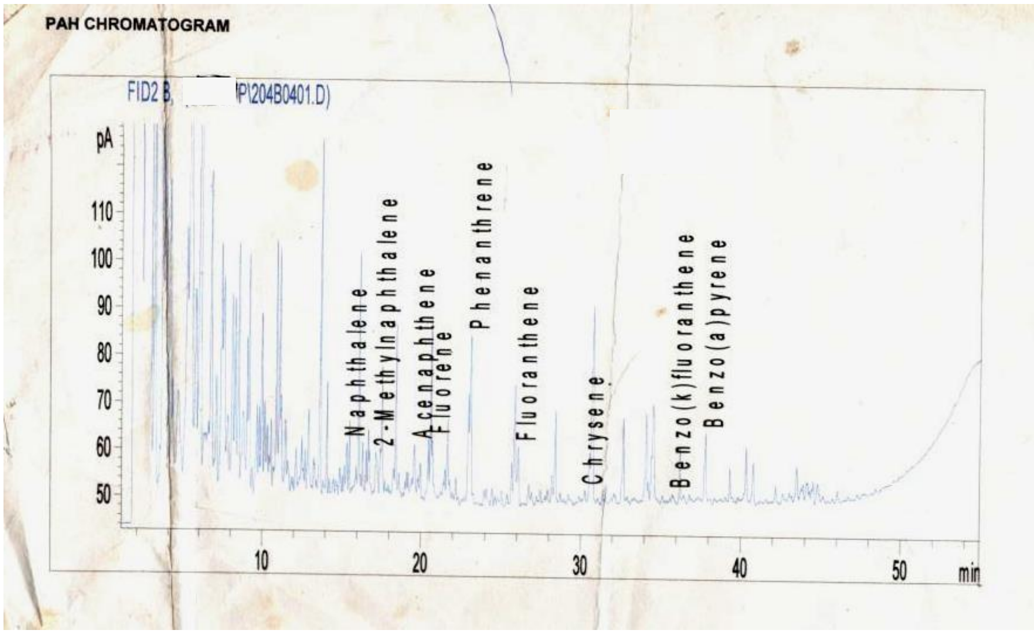
Among the three metals studies, zinc have the highest concentration followed by lead, this could be attributed to metal coating used in the ship for ballast water tank, Zn galvanized sheet which could have been eroded and finally released into the effluent (Al Mukaimi et al., 2018).The concentration of the elements investigated except Zn were high with respect to FEPA standard which will eventually pollute the water body the bacterial count was also high (Altug et al., 2012).

Table2: Polyaromatic Hydrocarbons (PAHs) from Ballastwater.

Components	S1	S2	S3	S4	S5
Napthalene	0.32	0.13	0.10	0.00	0.17
2-methylnaphthalene	0.53	0.03	0.14	0.09	0.10
Acenephthalene	0.17	0.02	0.04	0.03	0.12
Acenephthalene	0.621	0.01	0.31	0.02	0.04
Fluorene	0.58	0.31	0.04	0.01	0.10
Phenathrene	0.22	0.02	0.11	0.13	0.13
Anthracene	1.53	0.04	0.13	0.12	0.11
Fluorathene	0.67	0.03	0.05	0.60	0.31
Pyrene	0.31	0.21	0.02	0.04	0.05
Benzo(a)anthrene	0.03	0.04	0.05	0.03	0.06
Chrysene	0.02	0.01	0.02	0.03	0.02
Benzo(a)pyrene	0.03	0.04	0.20	0.03	0.02
Benzo(b)pyrene	0.16	ND	0.06	0.02	0.10
Benzo(k)fluorathrene	0.00	0.00	0.00	0.01	0.00
Indenol(1,2,3)pyrene	0.00	0.00	0.00	0.00	0.02
Dibenzo(ab)anthracene	0.00	0.00	0.03	0.00	0.00
Benzo(g,h,l)perlylene	0.00	0.00	0.01	0.00	0.01

Total	5.19	0.86	1.27	1.14	1.35

The result of analysis by gas chromatography for the polyaromatic hydrocarbons of five ships from Forcados in Burutu Local Government Area of Delta State are shown in table 2 and figure 2. From table1, S1 have higher concentration of PAHs than the other ships with all levels above WHO standard for aquatic lives.



The concentration of benzo(a)anthracene is just on the limit of 0.03ppm which affect the eyes. Phenathrene was high (0.21ppm) and this is usually derived from coal tar which could have been used as sealant in ships, this could be taken into the body through water and food. It destroys the kidney, liver and heart. Benzo(a)anthracene is found in smoked foods, from automobile exhaust and intermediates in chemical reactions (Darilmaz et al., 2019). Anthracene (1.53ppm), a light molecular weight hydrocarbon which causes skin rash and irritates the lungs was also higher than the standard limit. Fluorene which was detected at 0.58 ppm, causes birth defects, damages the liver and affects the abdominal region. This means that ballast is not safe to be disposed directly into the ecosystem especially for those ships used in transportation of petroleum products (Dos Santos et al., 2017). Chrysene was also found at elevated level with the value of 0.02 ppm. Napthalene was 0.321 ppm lower than that in some Nigeria river environment studied by Olayinka et al., (2019) of PAHs to be carcinogenic causing liver and lung cancers tumours and malignant lymphonic in mice. They may be derived from smoking from different sources, their presence have been contributed from ballast water from ships, leakages, engine boat tanks, transport processes in tank treatments (Sinaei & Mashinchian, 2014).
Ballast water treatment technologies are derived from municipal and industrial applications constrained by space, cost and efficiency with respect to the IMO discharge ballast water standard. However, no monitoring along the high seas of discharged water especially in Nigeria. (1,2,3)pyrene, dibenzo(a,b)anthracene and benzo(g,h,l)perlylene were not detected in ballast water from any of the ships.

These are high molecular weight hydrocarbons. The lower molecular weight hydrocarbons are more prevalence and volatile, more biodegradable than the high molecular weight hydrocarbons, which are more environmentally persistent and low water solubility and could be due to petroleum combustion (Freeman et al., 2019). From the results, the ballast water from ship S1 has values higher than Standards Organization of Nigeria (SON) values to be discharged into the river. It could bioaccumulate in aquatic organisms and sediments and be consumed through food chain. It is known that PAH undergo metabolism in vertebrates, whose products may be toxic (Umudi & Umudi, 2021).

Conclusion

This investigation showed that some parameters as dissolved oxygen, chloride, phosphate, bacteria count and poly aromatic hydrocarbons from ballast water are not good for aquatic lives. The introduction of pollutants is a growing threat to the conservation of biodiversity and ecosystem function. As a result, it has inflicted heavy cost on the society. Illegal discharge of ballast water, management, technical, administrative and legal infrastructure should be developed for transportation of dangerous goods, to prevent introduction of invasive species and pollutants from one region to another. Fishes, aquaculture and tourism sector will strive and contribute to the economic growth of the country, if effluents are properly treated before being discharged into the river. Work should be done on ballast water treatment to protect biodiversity. Further work should be done on PAHs in invertebrates and sediments to act as a baseline.

References

Ademoroti, C.M.A. (1996). Standard Methods for Water and Effluents Analysis. Foludex Press Ltd., Ibadan, p. 182.

Al Mukaimi, M.E., Kaiser, K., Williams, J.R., Dellapenna T.M., Louchouarn, P., and Santschi, P.H. (2018). Centennial record of anthropogenic impacts in Galveston Bay: evidence from trace metals (Hg, Pb, Ni, Zn) and lignin oxidation products. *Environmental Pollution*, **237**: 887-899. https://doi.org/10.1016/j.envpol2018.01.027. PMID:29361321.

Altug, G., Gurun, S., Cardak, M., Ciftci, P.S. & Kalkan, S. (2012). The occurrence of pathogenic bacteria in some ships' ballast water incoming from various marine regions to the Sea of Marmara, Turkey. *Marine Environmental Research*, **81**(10), 35-42. https://doi.org/10.1016/j.marenvres.2012.08.005.

APHA, 2017. Standard Methods for the examination of water and wastewater (23rd ed). American Public Health Association (APHA), Washington D.C.

Chen, Y.S., Kang, C.K., & Liu, T.K. (2022). Ballast water management strategy to reduce the impact of introductions by utilizing an empirical risk model. *Water*, **14**(6): 981. https://doi.org/10.3390/w14060981

Darilmaz, E., Alyuruk H., Kontas, A., Altay, O., Uluturhan E, & Bilgin, M. (2019). Distributions and sources of PAHS and OCPS in surficial sediments of Edremit Bay (Aegean Sea). *Archives of Environmental Contamination and Toxicology*, **77**(2): 237-248. doi.10.1007/50020044-019-00619-8.

Dos Santos, M.M., Goulart F., Fillippe, T.C., Reichert,G. & de Azevedo, J.C.R. (2017). PAHs diagnostic ratios for the distinction of petrogenic and pirogenic sources; applicability in the Upper Iguassu Watershed – Parana, Brazil. *RBRH* **22**. doi: http://dx.doi.org/10.1590/2318-0331.011716084.

Ebin, O.I. andAbua, M.A. (2019). Implementation of ballast water management control in Calabar River, Nigeria Port Authority, Cross-River State – Nigeria. *International Journal of Science and Engineering Research*, **10**(8): 699-706.

Ekere, N.R., Yakubu, N.M., Oparanozie, T., & Ihedioha, J.N. (2019). Levels and risk assessment of polycyclic aromatic hydrocarbons in water and fish of Rivers Niger and Benue confluence Lokoja, Nigeria. *Journal of Environmental Health Science and Engineering*, **17**(1): 383-392.doi: 10.1007/s40201-019-00356-z.

Freeman, L.A., Corbet, D.R., Fitzgerald, A., Lemley, D.A., Quigg, A., and Steppe, C.N. (2019). Impacts of Urbanization and Development on Estuarine Ecosystems and Water Quality. *Estuaries and Coasts*, **42**:1821-1838.

Gerhard, W.A., Lundgreen, K., Drillet, G., Baumler, R., Holbech, H., & Gunsch, C.K. (2019). Installation and use of ballast water treatment systems – implications for compliance and enforcement. *Ocean & Coastal Management*, **181**: 104907. doi: doi.org/10.1016/j.ocecoaman.2019.104907

Grmasha, R.A., Abdulameer, M.H., Stenger-Kovacs, C., Al-Sareji, O.J., Al-Gazali, Z., Al-Juboori, R.A., Meiczinger, M., &Hashim, K.S. (2023). Polycyclic aromatic hydrocarbon in the surface water and sediments along Euphrates River system: occurrence, sources, ecological and health risk assessment. *Marine Pollution Bulletin*, **187**:114566.

IMO (2004) International convention for the control and management of ship, ballast water and sediment. International Maritime Organization (IMO), London. http.//globallast.imo.org/monograph19 Economic Assessment web.pdf

Lv, B., Jiang, T., Wei, H., Tian, W., Han, Y., Chen, L., Zhang, D., & Cui, Y. (2021). Transfer of antibiotic-resistant bacteria via ballast water with a special focus on multiple antibiotic resistant-bacteria: a survey from an inland port in the Yangtze River. *Marine Pollution Bulletin*, **166**: 112166. https://doi.org/10.1016/j.marpolbul.2021.112166.

Ogidiaka, E., & Ikomi, B. (2021). Fish fauna composition, abundance and distribution of Forcados River estuary. *International Journal of Biological Innovations*, **3**(1): 139-147. https://doi.org/10.46505/IJBI.2021.3113.

Olayinka, O.O., Adewusi, A.A., Olujimi, O.O., & Aladesida, A.A. (2019). Polycyclic aromatic hydrocarbons in sediment and health risk of fish, crab and shrimps around Atlas Cove, Nigeria. *Journal of Health and Pollution*, *9*(24): 191204. doi.10.5696/2156-9614-9.24.191204.

Ruqayah, A.G., Csilla, S.K., Baydaa, A.H.B., Osamah, J.A., Raed, A.A., Monika, M., & Khalid, S.H. (2023). Ecological and human health risk assessment of polycyclic aromatic hydrocarbons (PAH) in Tigris river near the oil refineries in Iraq. *Environmental Research*, **227**, 11579. https://doi.org/10.1016/j.envres.2023.115791.

Salahuddin (2023[a]). Analysis of fish productivity in Mohabala Lake, Bhadravati, Maharashtra, India. *Oriental Journal of Chemistry*, 39(4), 1076-1081. http://dx.doi.org/10.13005/ojc/390436.

Salahuddin (2023[b]). Water Quality Analysis of Hebbal Lake, Bangalore, Karnataka, India for the survival of fishes. *Journal of Survey in Fisheries Science*, **10**(15): 5489-5498

Shang, L., Zhai, X., Tian, W., Liu, Y., Han, Y., Deng, Y., Hu, Z., & Tang, Y.Z. (2021). *Pseudocochlodinium profundisulcus* resting cyst detected in the ballast tank sediment of ships arriving in the ports of China and North America and the implications in the species' geographical distribution and possible invasion. *International Journal of Environmental Research and Public Health*, **19**(1): 299. doi.10.3390/ijerph19010299.

Sinaei, M., and Mashinchian A. (2014). Polycyclic aromatic hydrocarbons in the coastal seawater, the surface sediment and Mudskipper *Boleopthalmus dussumieri* from coastal areas of the Persian Gulf: source investigation, composition pattern and spatial distribution. *Journal of Environmental Health Science and Engineering*, **12**(59): https://doi.org/10.1186/2052-336X-12-59. PMID: 24612923.

Umudi, E.Q., & Umudi, O.P. (2022). Assessment of polynuclear aromatic hydrocarbon in marine sediments Delta State, Southern Nigeria. *Journal of Water Resources and Ocean Science*, *11*(4), 71-76. doi.10.11648/j.wos 2021104.12.

Wan, Z., Shi, Z., Nie, A., Chem, J., & Wang, Z. (2021). Risk assessment of marine invasive species in Chinese port introduced by the global shipping network. *Marine Pollution Bulletin*, **173**(Part A): 112950. https://doi.org/10.1016/j.marpolbul.2021.112950.