Physiochemistry and Microbiological Quality of Surface water Body Around Port Terminals in Southern Nigeria.

Original Research Article

Abstract

Anthropogenic activities around the sea ports are capable of causing changes on the physicochemical and microbiological quality of water bodies along the port terminals. Such activities can cause an ecological imbalance in the water quality /ecosystem resulting in extinction of aquatic resources. The aim of this study therefore was to investigate the physicochemical and microbiological quality of surface water along the busy port terminals. Surface water samples were collected from Onne port terminal using sterile containers. The samples were collected during the wet and dry seasons between January to June 2021. The sterile bottles were filled with surface water samples and transported in an ice packed container to the Department of Microbiology Laboratory of the Rivers State University for analyses using standard analytical methods. Statistical analyses were carried out using ANOVA and All pairs tukey-kramer. Results of the physicochemical parameters showed that temperature, total dissolved solids, total suspended solids, nitrate and heavy metals were significantly higher during the dry season than the wet season at $P \geq 0.05$ levels of significance. Seasonal variation with respect to microbial counts shows that Total Heterotrophic Bacteria, Total Heterotrophic Fungi, Total coliforms and Faecal coliforms had a mean value of $3.9\pm1.77 \times 10^6$; $0.8 \pm0.05 \times 10^4$; $7.4 \pm1.3 \times 10^4$ and $3.6 \pm0.17 \times 10^4$ colony forming unit per millilitre respectively for wet season while the dry season had $1.6\pm0.77 \times 10^6$, $0.5 \pm0.01 \times 10^4$, $4.6 \pm0.17 \times 10^4$ and $2.7 \pm1.03 \times 10^4$ cfu/ml respectively. In this study, the predominant bacterial isolates belonged to the genera of *Vibrio, Pseudomonas, Klebsiella, Bacillus, Shigella, Staphylococcus, Salmonella, Proteus, Bacillus* and *Escherichia. coli*. The results of physicochemical and microbiological characteristics including the heavy metals, were detected at concentrations on or below detection limits.. It is therefore suggested that relevant environmental regulatory bodies should maintain regular check to ensure that appropriate standards are maintained around seaports due to beehive of activities.

Keyword: Port Terminals, Microorganisms, Physico-chemistry, Anthropogenic activities, Surface water body

1.0: Introduction

"Water is an Indispensable and multipurpose natural resource and exist in the three states of matter; gaseous, liquid and solid phases" (Obire *et al.*, (2003). The chemical composition of surface water is derived from atmospheric, soil and rock sources. Water is a valued natural resource for the existence of all living organisms. Water is used for domestic activities, irrigation in agriculture, as a means of transportation and recreational activities among others (Ogbonna and Orinya, 2018). Water quality monitoring and evaluation is a major step to water quality management; thus, there has been an increasing demand for monitoring water quality of many rivers by regular measurements of various water quality variables (Bartam & Balance, 1996). "The relative distribution of the chemical composition to surface waters from each of these sources is a function of the climate being modified by increasing human activities. Water is an abundant natural resource, crucial for the sustenance in all aspects of life and it is a valuable resource that needs to be well-cared-for" (Adejuwon and Adelakun, 2012). The increasing human population, urbanisation, industrial activities and expanding food production and processes and other various activities around the sea port terminals pose a lot of pressure on water resources. (Ngah *et al.*, 2017). **"**The river water quality is influenced by a range of factors such as weather, surface water runoff, and waste discharge from various operations around port terminals which result in changes in water quality parameters" (Ogbonna *et al.*, 2021). "This can be observed in the variation of the impact that port activities such as shipping, dredging, ballast water discharges, storage and transportation of hazardous materials can have on receiving waters" (Simpi, 2011). More so, Industrial activities around sea ports have contributed to the widespread contamination of global marine and estuarine ecosystems with heavy metals and other pollutants that tend to be persistent; many are essentially permanent additions to the environment and are also often highly toxic to biota

According to Lawson (2011), Sea port activities, particularly ship operations are the prime factor causing maritime pollution around port terminals .Other port activities like shipping, dredging, ballast water discharges, storage and transportation of hazardous materials generate several wastes such as industrial effluents, sewage, urban and river runoff, natural seepage, offshore oil production, ships, and others into the environment thus, causing pollution of coastal waters and the sounding environment (Bailey and Solomon, 2004); soil (Ogbonna *et al.*, 2007) and water resources (Gupta *et al* 2015). Untreated water and faecal contamination of surface water can serve as the major vehicle of pathogen spread and other environmental health hazard. The presence of microbial pathogens in polluted, untreated and treated water poses a considerable health risk to the general public (Meme *et al.,* 2014). "Routine microbiological monitoring of surface water for pathogenic bacteria is required, as a measure to prevent the spread of water borne diseases such as diarrhea, dysentery and typhoid" (Ochuko and Thaddeus, 2013; Ogbonna, 2014). The spectrum of water borne infections is also expanding, and many infectious diseases once believed to be conquered are on the rise. The present study is therefore aimed at evaluating the impact of port activities on the physiochemical and microbiological quality of surface water body around sea ports in southern Nigeria.

Materials and Methods

2.1 Description area of Study

The study was carried out at the Federal Ocean Termina Onne in Eleme Local Government Area of Rivers State. Onne is where one of the two prominent sea ports for oil and gas exploration is sited with beehive of activities for transportation with different ocean vessels.

2.2. Sample collection

Surface water samples were collected from Onne and Warri port terminals at five (5) different stations with sterile containers. Surface water samples were collected from both ports between January to June 2021 over a period of six months covering both wet and dry seasons. Each sample bottle was rinsed with the appropriate water sample before final collection. The sterile bottles were filled with surface water and transported in an ice packed cooler to the Department of Microbiology Research Laboratory at the Rivers State University for analyses.

2.3: Microbiological analyses

Microbiological analysis of the water samples included isolation and characterization of total cultural aerobic heterotrophic bacteria using nutrient agar (Oxoid) media and total coliforms and faecal coliforms using standard analytical methods according to methods prescribed by Prescott *et al* (2005).

2.4: Identification of Bacterial Isolates

Cultural morphological characteristics (pattern of growth, pigmentation and appearance/sizes and shapes on plates) were observed after 18-24 hours of incubation at 37°C; Cell morphology (Gram reactions) and other biochemical tests of the isolates were done. Further identification was made by comparison of their cultural, morphological and physiological characteristics with those of known taxa using the Bergey's Manual of Determinative Bacteriology (Holt *et al.*, 1994). Molecular analysis was also carried out on isolates for more information on their genome.

2.5: Physico-chemical Characteristics

The quality of surface water is based on certain physicochemical properties such as pH, Electrical conductivity, Dissolved oxygen, biological oxygen demand, total dissolved solids, etc were measured using their respective meters. pH was measured using a pH meter (HANNA, HI 9125) and conductivity, total dissolved solids using a calibrated Conductivity Meter (HANNA, Conductivity meter). Turbidity measurements was conducted using a portable turbidity meter (APHA, 2012). Total hardness was evaluated by burette titration. Total alkalinity, chloride, nitrate-N, sulfate and major cations were determined according to other standard analytical methods described by APHA (1995). The heavy metals concentrations were determined using the Atomic absorption spectrophotometer (AAS) in duplicates and the mean values recorded as standard deviation.

3.0 Results and Discussion

The results of the physico-chemical parameters and microbial counts of surface water obtained from Onne Port terminals during the 6-month period are presented in Table 1. Seasonal variation with respect to microbial counts showed that Total Heterotrophic Bacteria, Total Heterotrophic Fungi, Total coliforms counts and Faecal coliforms counts recorded a mean value of $3.9 \pm 1.77 \times 10^6$, $0.8 \pm 0.05 \times 10^4$, $7.4 \pm 1.3 \times 10^4$, and $3.6 \pm 0.17 \times 10^4$ colony forming unit per millilitre respectively for wet season while dry season had $1.6 \pm 0.77 \times 10^6$, $0.5 \pm 0.01 \times 10^4$, $4.6 \pm 0.17 \times 10^4$ and $2.7 \pm 1.03 \times 10^4$ cfu/ml respectively. Also, ten (10) bacterial isolates belonging to the genera *Vibrio, Pseudomonas, Klebsiella, Bacillus, Shigella, Staphylococcus, Salmonella, Proteus, Bacillus and E. coli* (Figure 1 and 2) were obtained.

The presence of these microorganisms particularly *E. coli* in the surface water body is universally accepted to indicate fecal contamination and possible presence of other pathogenic organisms (Reynolds, 2016). *E. coli* is a subgroup of fecal coliforms used as an indicator of fecal contamination. Although vast majority of *E. coli* are completely harmless, some strains of the bacteria have acquired genetic capabilities which enable them to encode virulence factors (Meregini-Ikechukwu *et al.*, 2020). Pathogenic *E. coli* strains cause diverse forms of bacterial induced illnesses with symptoms ranging from mild diarrhoea to severe complication and even death (Rocourt, 2013).

As summarized in Table 1 below, certain physiochemical parameter such as temperature, total dissolved solids, total suspended solids, nitrates as well as heavy metals were significantly higher during the dry season at $P \geq 0.005$ level, than the wet season of the surface water along the port terminals and were above the permissible limits which indicates contamination of the water bodies due to port activities in these regions. These values could trigger serious pollution of the surface waters which now gives rise\ to high microbial counts and presence of feacal coliforms which may be introduced during runoff, seepage of waste products through sewer lines from different sources and discharge of waste products and wastewater thus enriching the ecosystem with excess nutrients to cause eutrophication. This may in turn result to ecological imbalance of the surface waters causing fouling and deaths of aquatic organisms

and possibly extinction of vital species in the rivers. The pH range for optimum growth for most aquatic bacteria is pH 6.5 and 8.5 (Rheinheimer 1974), which include the range of values reported in

Parameters	t-test	WHO 2003 Limit

this study and for surface water from Onne port terminals.

Table 1 : Physicochemical and Microbiological Characteristics of Surface water from Onne Port Terminals

	Dry	Wet		
pH	5.6±0.15	6.72±0.24	**<0.0001***	**6.5-8.5**
Temperature	30±1	26.6±0.54	**0.0002***	NS
Electric Conductivity (μS/cm)	14168±1.90	1847.2±2.30	**0.0035***	1000
Total Dissolved Solid	2622±1.70	917.2±2.70	**<0.0001***	500
Total suspended solid	7.6±0.54	1.4±0.548	**<0.0001***	25
Dissolved Oxygen	2.08±0.19	3±0.6	**0.0114***	
Biological Oxygen Demand	0.78±0.19	0.8±0.25	0.8921	5.0
Chemical Oxygen Demand	1.56±0.38	1.6±0.51	0.8921	NS
Turbidity	0.2±0	0.14±0.05	**0.0400***	1
Bromine	0.6±0	0.2±0	**<0.0001***	0.5
Chlorine	0.3±0	0.1±0	**<0.0001***	
Nitrate	5.98±0.74	0.262±0.06	**<0.0001***	45
Sulphate	694±1.9	250±2.01	**0.0080***	200
Phosphate	2.316±0.44	0.844±0.21	**0.0002***	
Lead Pb	0.647±0.10	<0.001±0	**<0.0001***	0.01
Nickel Ni	0.42±0.04	<0.001±0	**<0.0001***	
Zinc Zn	0.18±0.016	0.015±0.08	**<0.0001***	5.0
Iron Fe	0.791±0.151	0.531±0.143	**0.0234***	0.05
Copper Cu	0.064±0.009	0.018±0.015	**0.0004***	0.05
Cobalt Co	0.43±0.047	0.21±0.095	**0.0016***	0.05
Chromium Cr	<0.001±.0	<0.001±.0	1	0.05
Cadmium Cr	0.115±0.007	0.1±0.004	**0.0033***	0.01
Magnesium	18.72±1.495	69.775±3.013	**<0.0001***	0.05
Total Petroleum Hydrocarbon (TPH)	0.184±0.065	0.252±0.008	0.5075	0.05
Polycyclic aromatic hydrocarbon (PAH)	0.004±0.002	0.005±0.004	0.7518	0.02
Total Heterotrophic Bacteria (cfu/ml)	1.6±0.77 x 10^6	4.4±1.91.2 x 10^6	**0.0004***	100
Total Heterotrophic Fungi (cfu/ml)	0.8 ±0.51 x 10^4	1.6±0.05 x 10^4	**0.0002***	0
Total Coliform (cfu/ml)	4.6 ±1.79 x 10^4	3.9±0.81 x 10^4	0.108	0
Feacal coliform (cfu/ml)	2.7 ±0.03 x 10^4	1.8±0.44 x 10^4	**<0.0001***	0

T-test with asterisks show significant different at $P \geq 0.05$

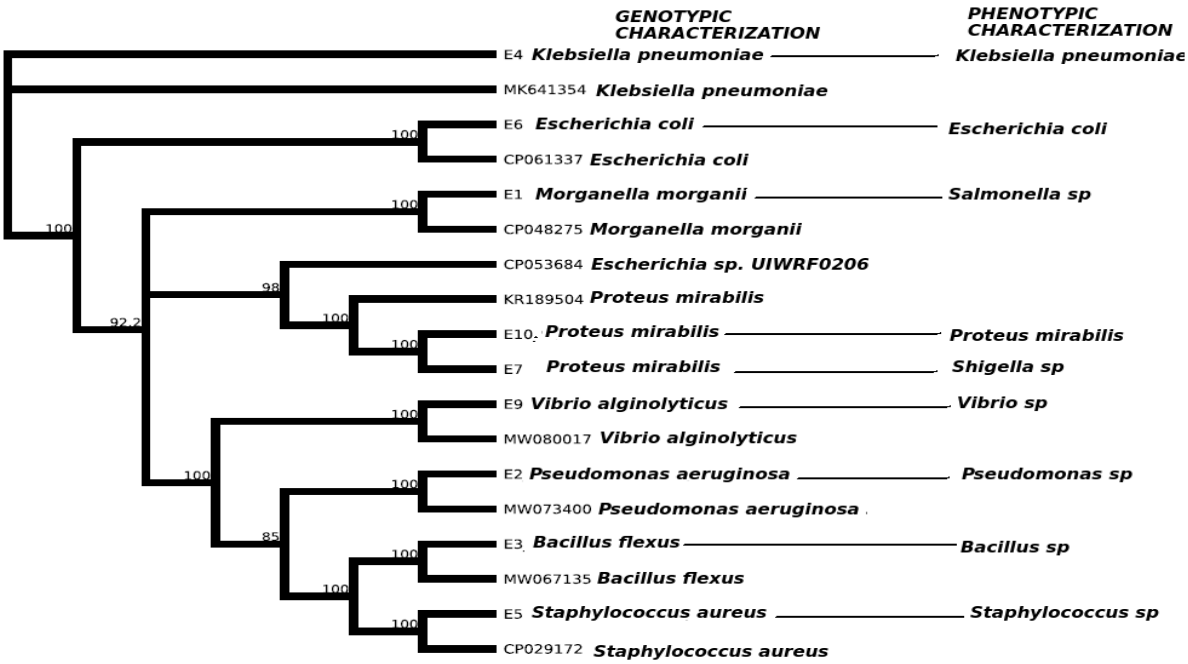

Fig 1: **Evolutionary distances between the bacterial isolates**

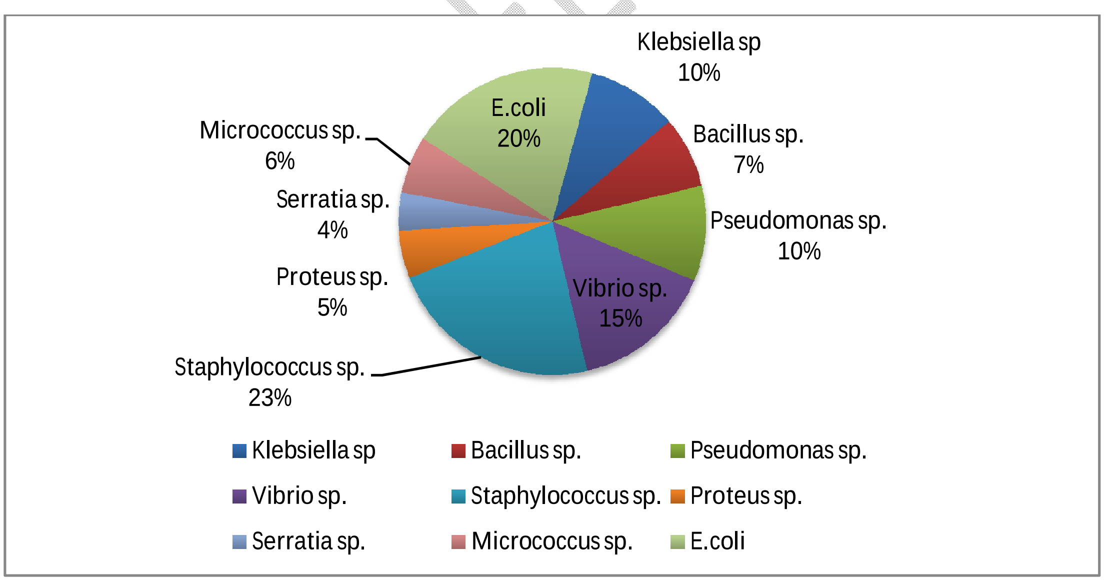

Figure 2: Percentage Occurrence of the Bacterial Isolates

The seasonal variation of the physicochemical parameters showed that the pH which is a measure of the hydrogen ion concentration of the water determines the acidity or alkalinity of a water body, pH determines the type of aquatic species that can inhabit the natural and wastewaters. Generally, pH values obtained in the present study shows slightly acidic water (5.6) for the dry season, and slightly alkaline (6.72) for the wet season. The mean pH values for the dry season were below the acceptable range of 6.5 - 8.5 as prescribed by WHO (2003). The pH range for optimum growth of most aquatic bacterial species falls between pH 6.5 and 8.5 (Rheinheimer, 1974), which was reported in this study. Biochemical Oxygen Demand (BOD_5) is used as an index to determine the amount of dissolved oxygen required by aerobic bacteria to decompose organic materials and also enhance biological activity in the water. Hence high concentrations of BOD is an indication of organic pollution which otherwise can result to ecological imbalance and fouling of the water bodies which can adversely affect aquatic life. The BOD mean values in this study for Onne surface water ranged from 0.8±0.25 mg/L, for the wet season (Table 1), and from 0.78±0.19 mg/L, with mean value of 6.14 mg/L for the dry season. Very low BOD values of 0.78±0.19 mg/L was reported during the dry season sampling at Onne port terminal. Ephraim and Ajayi (2015) interpreted low BOD values as an indication of limited levels of organic matter decomposition requiring oxygen from the water.

Heavy metals occur naturally as elements with high atomic weight and density which is at least 5 times greater than water, they can mostly be found in industrial, domestic effluents, agricultural, medical and technological applications and this can lead to a wide distribution of their concentrations in the environment, which poses a threat to human health and the environment. Their level of toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as status of exposed individuals and environment. Due to their high degree of toxicity, these metallic elements are of public health significance and considered as systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure (Paul *et al.*, 2012). Heavy metal concentrations of copper (Cu), chromium (Cr), manganese (Mn), and cadmium distribution has been one of the critical concerns in natural environments due to their toxicity and biomagnification attributes in sea foods and animal species. Many regulations have been established to avoid heavy metal concentrations in the environment especially in waters to exceed quality criteria for environmental protection. However, anthropogenic activities such as port activities have discharged significant amounts of heavy metals into surface water and rivers. Metal bioaccumulation in surface waters threatens ecosystems, reservoirs and habitats or food sources for aquatic fauna and flora due to the potential of metal mobilization and the subsequent uptake into food web.

Conclusion

The results of physicochemical characteristics of surface waters in this study has helped to ascertain the water quality of water bodies around sea port terminals and human activities along the ports indicate that the surface waters are highly impacted by human activities. Parameters such as turbidity, DO, BOD, total heterotrophs and total coliform counts were not within permissible limits of interim standards for drinking water. The high bacterial population is as a result of increased nutrient load from the various activities along sea port which contributed to the organic load of the water thereby causing pollution. Most bacteria isolated are potential pathogens of various diseases affecting man and other animals. Some of them may find their way through the beehive of anthropogenic activities or through runoff, seepage of sewage, indiscriminate defaecation and dumping of wastes without treatment. In addition to poor environmental regulatory activities by relevant agencies to monitor and control the excesses of users of the ports for business. This predisposes the water bodies to regular pollution contributed by port activities like shipping, dredging, ballast water discharges, storage and transportation of hazardous materials that generate several wastes such as industrial effluents, sewage, urban and river runoff, natural seepage, offshore oil production, ships, and others into the environment thus, causing pollution of coastal waters and the sounding environment. Therefore, the presence of *Escherichia coli* which is an indicator of faecal pollution and other coliforms is sufficient to conclude that the water is highly polluted with pathogenic organisms which are able to initiate different enteric diseases. Therefore, proper waste management approach/practice by relevant authorities and personal hygiene should be maintained during operation at port terminals to avoid cross contamination of the environment.

REFERENCES

Adejuwon J. O. and Adelakun M. A., (2012). Physiochemical and bacteriological analysis of surface water in Ewekoro Local Government Area of Ogun State, Nigeria: Case study of Lala, Yobo and Agodo Rivers, *International Journal of Water Resources and Environmental Engineering*, 4(3), 66-7

APHA (American Public Health Association). (2012) Standard Methods for the Examination of Waters and Wastes Water, 20th ed. Washington, D. C., 1-161.

Bartam J, and Balance R. (1996). Water quality monitoring: A practical guide to the design of freshwater quality studies and monitoring programme, Published Behalf of UNDP and WHO Champman and Hall, London. 383. ISBN 0-419-21730-4.

Gupta, A.K; Ephraim, B. E. & Ajayi (2015). The Complete Technology Book on Biofertilizer and Organic Farming. *National Institute of Industrial Research* press India.;242-253.

Holt, J.G; N.R. Kreig, P.H.A. Sneath, J.T. Stanley and Stanley S.T. (1994). *Bergey's Manual of Determinative Bacteriolog*y. Baltimore, USA; William and Wilkins.

Lawson E. O. (2011). Physico-chemical parameters and heavy metal concentration of water from the mangrove swamps Of Lagos Lagoon, Lagos, *Nigeria*. *Advances in biological Research* 5(1):08-21.

Meme F. K; Arimoro F. O and Nwadukwe F O. Analyses of physical and chemical parameters in surface waters nearby a cement factory in North Central, Nigeria. *Journal of Environmental Protection*. 2014;5:826-834.

Meregini-Ikechukwu, P. C; Ogbonna1 D. N and Akani N. P. (2020). Water Quality Assessment of Elechi Creek Receiving Effluent Discharges from Industrial Activities in Port Harcourt, *Nigeria Journal of Advances in Microbiology* 20(8): 21-30,

Ngah, A.S; Braide, S, and Dike C.C. (2017) Physico- chemistry of elechi creek in the upper bonny estuary, Rivers State, *Nigeria. Journal of Geoscience and Environment Protection*. 2017;5:181-197.

Obire, O; Tamuno, D.C., and Wemedo, S.A. (2003). "Physicochemical Quality of Elechi Creek in Port Harcourt, Nigeria". *J. Appl. Sci. & Environ. Mgt,* 7 (1): 43 – 49.

Ochuko, U and Thaddeus, O (2013). Effect of underground on-site sewage disposal system on the quality of water from hand dug wells in the urban centre of Ughelli, Delta state Nigeria. *Standard J of Education and Essay* 1(6): 81-90

Ogbonna D.N (2014). Performance Evaluation of Biozyme 1070 as Organic Waste degrader for Septic tanks in high water table areas of the Niger Delta, Nigeria. *International Journal of Waste Management and Technology:* 2, (3), 1 - 11, Ogbonna D.N; John O O, and Lucky B K. Influence of anthropogenic activities on the physico-chemical characteristics of open drainage channels in Port Harcourt. *Asian Journal of Advanced Research and Reports*. 2019;3(1):1-10.

Ogbonna D.N; Amangabara G T and Ekere T O (2007) Urban Solid Waste generation in Port Harcourt Metropolis and its implication for Waste Management. *Management of Environmental Quality: An International Journal* 18 (1): 71 – 88.

Ogbonna, D N and Orinya, O (2018). Physico-chemical and Microbiological Characteristics of a River Mud as substrate for Biological Generation of Electricity in the Niger Delta, Nigeria *Microbiology Research Journal International* 25(2): 1-14.

Ogbonna, D N; Ngah, S A and E. M. Anthony, E M (2021). Effect of Port Activities on the Physicochemical and Microbiological Quality of Surface Water in Warri and Onne Port Terminals. *Nigeria Journal of Applied Life Sciences International* 24(2): 46-57

Paul, B.T; Clement, G.Y, Anita, K.P, and Dwayne, J.S. (2012). *Heavy metals toxicity and the environment national institute of health.* 101:133–164.

Prescott, L.M; Harley, J.P. and Klein, D.A. (2005). *Microbiology*. 6th ed. McGraw Hill, London. pp. 135-140.

Rheinheimer, G. (1974). "Aquatic Microbiology". London: John Wiley and Sons Ltd., 24 – 108.

Rocourt, A. (2013). Basic groundwater hydrology. U.S. *Geological Surveys Water-Supply Papers* No. 2220, 78

Simpi B.; Hiremath S. M., Murthy, K. N. S., Chandrashekarappa K. N., Anil, N. P., and Puttiah, E. T., (2011). Analysis of Water Quality Using Physicochemical Parameters Hosahalli Tank in Shimoga District, Karnataka, *India.Global Journal of Science Frontier, Research*. Vol. 1(3), 31-34

World Health Organisation (2003). "Guidelines for Drinking Water Quality". 2nd edn., Vol. 2. *Health Criteria and Other Supporting Information. WHO*. 940-949.