Journal of
Clinical & Medical Images
Case Reports

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Physico-chemical analysis of hospital water in selected secondary health facilities in Bayelsa state, Nigeria

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Abstract

In secondary healthcare facilities in Bayelsa State, Nigeria, this study analyses the physico-chemical characteristics of the hospital water. Five secondary healthcare facilities in total were chosen at random from the State's three senatorial regions. DK, CHE, GHS, CTH, and GHK were the labels used for the healthcare facilities. The collection and analysis of water were conducted using conventional field and laboratory techniques.

The study's findings revealed that water samples' pH values ranged from 6.7 to 7.6 and are within the limit of permissible pH by World Health Organization (WHO) of 6.5 to 8.5 for potable water. The electrical conductivity of the samples range from 70µS/cm to 106µS/cm and the total dissolved solids (TDS) range from 46mg/l to 75mg/l and both parameters were within the WHO acceptable limits. The concentration level of Iron (Fe) ranges from 0.003mg/l to 0.1 mg/l and satisfied the WHO highest desirable level. The concentration of Lead (Pb) ranges between <0.001mg/l to 0.075 mg/l, while Magnesium (Mg) concentration was from 0.3mg/l to 0.4mg/l. The concentration level of Copper (Cu) ranges from <0.001mg/l to 0.121mg/l. The Dissolved oxygen in the water samples range from 9.2mg/l to 17.5mg/l which is above the permissible threshold of WHO. Based on the results from this study, there is the need for regular hospital water quality monitoring and treatment as part of infection disease control strategies in healthcare facilities.

Received: Jan 02, 2024

Accepted: Jan 30, 2024

Published Online: Feb 06, 2024

Keywords: Physico-Chemical; Hospital Water; Water Quality; Health Facility.

Cite this article: Ogbonna PC, Oparaocha ET, Anyanwu EC, Innocent DC, Physico-chemical analysis of hospital water in selected secondary health facilities in bayelsa state, Nigeria. J Clin Med Images Case Rep. 2024; 4(1): 1621.

Introduction

Water is a vital naturally occurring element and a useful resource for household, industrial, medical and agricultural purposes [1]. Though water is essential for sustaining life the inaccessibility of safe and potable water has been reported as a major cause of morbidity and mortality [2, 3]. According to the World health Organization (WHO), one in every three persons globally lack access to safe drinking water, two out of every five people lack access to a basic hand-washing facility with soap and water, and more than 673 million people continue to practice open defaecation and about 2 billion people drink water that has been polluted by faeces [4]. Nigeria is endowed with wate resources yet, only 19% of Nigeria's population has access to clean and safe drinking water. This water stress and scarcity shows that the country is unable to protect and/or use abundantly available water sources for socioeconomic development and environmental sustainability [5]. United Nations' sustainable development goal number 6 (SDG6) is all about access clean water and Sanitation by all which entails ensuring availability and sustainable management of water and sanitation for all by the year 2030 [6].

Water is essential for daily activities of the workers and patients in healthcare facilities (HCFs) as it aids in patients' care and maintaining sanitation. It is needed for administration of medication, for drinking, cooking, hand hygiene, ambulatory services, bathing, for cleaning rooms, beds, floors, toilets, sheets and laundry, and other environmental sanitation services so as to reduce the risk of infections transmission [3]. According to World Health Organization guidelines for water in healthcare facilities, the main water source must be an improved one, located on the premises and should be available all the time [4]. It is at the centre of patients' experiences of health care, because it enables them to remain hydrated, and to reduce the risk of contacting infectious diseases. Safe water in healthcare facilities helps in protecting people from diseases, controls nosocomial infections and hence reduces the chances of visiting and re-visiting hospitals. Proper utilization of wash, sanitation and hygiene (WASH) facilities in healthcare settings is considered as a cornerstone for providing good quality health care because it is estimated that about 1.8 million people die annually from diarrhoeal diseases which is heavily linked to consumption of contaminated water [7].

It has been noted by the World Health Organization that about quarter of HCFs worldwide lack basic water services, exposing 1.8 billion people at risk, especially the most vulnerable groups of the population, such as healthcare workers and patients that attend HCFs.

Contamination of hospital water with potentially pathogenic organisms and chemical pollutants is not uncommon [8]. The hospital water should be free of various organic and inorganic pollutants and all its parameter should be within the permissible limits mentioned by standard procedure of World Health Organization [9]. Water quality used in healthcare facilities has a significant impact on public health [10]. Pollutants such as bacteria, heavy metals, nitrates, and salts may contaminate water bodies as a result of insufficient treatment of wastes before discharging into water bodies or natural occurring disasters like flooding, hence such water cannot be directly used for basic needs especially in the healthcare facilities [11,12,13]. Natural levels of metals and other chemicals exceeding the acceptable limit can be injurious to human health even in the absence of human sources of pollutants in water [14]. The chemical and physical qualities of water may influence consumer perceptions and acceptance [15, 16]. Frequent treatment and evaluation of drinking water quality is imperative to make sure that trace elements do not exceed acceptable limits because of their hazardous effects at elevated levels, which may include mutagenicity, mortality, growth retardation, and structural malformations [17]. It is against this background that this study analyses water utilized by patients, healthcare workers, visitors, janitors etc in selected secondary healthcare facilities in Bayelsa State, South – South of Nigeria.

Methods and materials

This was an institutional based study which utilized simple random sampling to select 5 secondary HCFs from the 3 senatorial zones of the state for the study. Bayelsa State is one of the largest oil producing state in the Niger Delta region of Nigeria. It is a wetland so heavily endowed with water resources, and other natural resources. Bayelsa State is bordered in the south by the Atlantic Ocean, northwest by Delta State, and northeast by Rivers state. Approximately, the State is 90% water, and 10% land [18]. The collection and analysis of water from these HCFs were conducted using conventional field and laboratory techniques. Data was analysed using mean values and reported using World Health Organization's permissible limits as standard.

Results and discussions

Electrical conductivity: Electrical conductivity of water is the ability of water to allow the passage of electric current. Pure and potable water should rather be a good insulator than a good conductor of electric current. The increase in water conductivity poses little direct health risk; however, it is associated with poor-tasting of the water leading to consumers' dissatisfaction. Also, increased conductivity can also indicate that the water may have become contaminated and this contamination could cause corrosion of pipes with time [19]. In this study, electrical conductivity of the hospital water sampled ranged from 70 µS/cm to 106 µS/cm and this is within WHO permissible limit.

Total dissolved solids: According to WHO, the palatability of

Table 1: Physical parameters of hospital water in selected secondary healthcare facilities in Bayelsa State.

Parameter	WHO permissible limit	DK	CHE	GHS	CTH	GHK
Electrical Conductivity µS/Cm	300 - 1500	99	79	70	106	89
TDS (Mg/L)	150 – 1000	46	75	49	57	66
Temp (°C)	25-35	30	29	25	27	27
Colour (TCU)	5-15	10	2	2	3	7
Turbidity (NTU)	5	6	0.420	0.416	0.04	0.05

Table 2: Chemical parameters of hospital water in selected healthcare facilities in Bayelsa State.

Parameter	WHO permissible limit	DK	CHE	GHS	CTH	GHK
pH	6.5 – 8.5	6.7	7.6	7.2	6.7	7.5
Nitrate (mg/l)	45	31.6	20.8	21.5	20.0	34.6
Sulphate (mg/l)	250-500	5.82	5.82	5.79	5.11	5.80
D.O (mg/l)	5	4.7	9.2	12. 4	14.2	17.5
Iron Fe (mg/l)	0.3	0.1	0.007	0.085	0.003	0.021
Magnesium(Mg) (mg/l)	50	0.30	0.40	0.40	0.37	0.30
Lead(Pb) (mg/l)	0.05	0.044	<0.001	<0.001	0.075	<0.001
Copper (Cu) (mg/l)	1.0 – 2.0	<0.001	0.121	<0.001	<0.001	<0.001
Total Hardness	100-300	58.123	134.21	114.84	133.39	85.011

water with a total dissolved solids (TDS) level of less than about 600 mg/l is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l [20]. The presence of high levels of TDS may also be unacceptable to consumers because it can lead to excessive scaling in water pipes, heaters, boilers and household appliances. The water samples from the healthcare facilities had total dissolved solids ranging from 46mg/l to 75mg/l and this is within the ceiling amount by world health organization.

Temperature: high water temperature enhances the growth of microorganisms and may increase problems related to taste, odour, colour and corrosion. WHO had ordinarily not placed a health-based guideline value for temperature of water, however, ambient temperature ranging from 25 oC to 35oC have been recommended and the water samples in the study have temperature within the recommended standard.

Colour: is measured in true colour unit (TCU). Drinking-water should ideally have no visible colour. Colour is strongly influenced by the presence of organic matter, iron and other metals, either as natural impurities or as corrosion products. It may also result from the contamination of the water source with industrial effluents and may be the first indication of a hazardous situation. The source of colour in a drinking-water supply should be investigated, particularly if a substantial change has taken place. Levels of colour below 15 TCU are often acceptable to consumers. All water samples in the study were within the limit as they ranged from 2NTU to 10NTU

Turbidity: measured in nephelometric turbidity units (NTU) is the cloudiness of water caused by suspended particles, chemical precipitates, etc. It reduces the clarity of water to transmit light and hence reduces the acceptability of drinking-water. Although most particles that contribute to turbidity have no health significance (even though they may indicate the presence of hazardous chemical and microbial contaminants), many consumers associate turbidity with safety and consider turbid water as being unsafe to drink. Any complaints about unexpected turbidity should always be investigated because they could reflect significant faults or breaches in distribution systems. One of the sampled water (DK) is above WHO permissible limit of 5NTU and therefore requires further investigation.

pH: the optimum pH required will vary according to the composition of the water and the nature of the construction materials used in the distribution system, but it is advisable to be in the range 6.5–8.5. All water samples in the study were within standard limit of WHO.

Nitrate: there have been assumptions that nitrate in drinking-water could be associated with congenital malformations and appears to competitively inhibit iodine uptake, with the potential for an adverse effect on the thyroid. There have also been suggestions of an association between nitrate in drinking-water and the incidence of childhood diabetes mellitus. World Health Organization has place health-based limit of Nitrate in water at 45mg/l to 50mg/l and all water samples from the selected secondary health facilities in the study was found to be within this acceptable limit.

Sulphates: the presence of sulphate in drinking-water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers and may contribute to the corrosion of distribution systems. The existing data do not identify a level of sulphate in drinking-water that is likely to cause adverse human health effects. However, because of the gastrointestinal effects resulting from ingestion of drinking-water containing high sulphate levels, it is recommended that health authorities be notified of sources of drinking water that contain sulphate concentrations in excess of 500 mg/l. All water samples from the health facilities were within the permissible limit in World Health Oorganization guideline.

Dissolved oxygen: the dissolved oxygen content of water may be influenced by the source, the temperature, the treatment, and chemical or biological processes taking place in the distribution system. Depletion of dissolved oxygen in water supplies can encourage the microbial reduction and can also cause an increase in the concentration of ferrous iron with subsequent discoloration at the tap when the water is aerated. No health-based guideline value is recommended. However, very high levels of dissolved oxygen may exacerbate corrosion of metal pipes. Therefore, it may be reasonable to keep the dissolved oxygen within 5mg/l. with the exception of DK, all health facilities in the study had high level of dissolved oxygen quite above the permissible limit recommended by World Health Organization.

Iron: this is found in natural fresh waters at levels ranging from 0.5 to 50 mg/l. Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures because turbidity and colour develops. All water samples in the study conformed to the ceiling amount for Iron in water as recommended by

World Health Organization.

Magnesium: is a natural constituent of water. It is an essential for proper functioning of living organisms. Human body contains about 25 g of magnesium (60 % in bones and 40 % in muscles and tissues). According to World Health Organization standards, the permissible range of magnesium in water should be 50 mg/l and all water samples in the study were within this limit.

Lead: exposure to lead is associated with a wide range of effects, including various neuro-developmental effects, impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes. World Health Organization has a provisional health-based guideline value of 0.01 mg/l – 0.05mg/l for Lead. The primary source of Lead in water could be from service connections and plumbing in buildings. All water samples analyzed except one (CTH) had Lead at a permissible amount recommended by World Health Organization. This calls for concern and proper investigation as the presence of Lead in water, no matter how small is deleterious to health

Copper: is both an essential nutrient and a drinking-water contaminant. It is used to make pipes, valves and fittings and is present in alloys and coatings. Copper concentrations in drinking-water vary widely, with the primary source most often being the corrosion of interior copper plumbing. High concentrations of copper can interfere with the intended domestic uses of the water. Staining of sanitary ware and laundry may occur at copper concentrations above 1 mg/l. At levels above 5 mg/l, copper also imparts a colour and an undesirable bitter taste to water. Although copper can give rise to taste, it should be acceptable at the health-based guideline value of 2 mg/l. All water samples studied were within the World Health Organization permissible limit.

Hardness: this is usually indicated by precipitation of soap scum and the need for excess use of soap to achieve cleaning. In some instances, consumers tolerate water hardness in excess of 500 mg/l. Depending on the interaction of other factors, such as pH and alkalinity, water with hardness above 200 mg/l may cause scale deposition in the treatment works, distribution system and pipework and tanks within buildings. It will also result in high soap consumption and subsequent “scum” formation. All water samples for this study were found to be within the ceiling value for hardness of water.

A similar study was carried out by Rim on water samples of emergency departments from 11 general hospitals of the Syrian Coast [21]. The samples were collected twice in sterilized flasks; to evaluate the physiochemical and microbial properties of hospital water. The samples were analyzed for pH, turbidity, electrical conductivity, total dissolved solid (TDS), percentage of salts , Ammonia, Nitrate, Nitrite, Sulphate, Phosphate, Copper, Iron, Chloride, as well as the microbial analysis. Results showed that the physicochemical values of hospital water samples were within the permissible limits of standard procedure mentioned in Syrian standards S.N.S:45/2007 and World Health Organization standards.

Conclusion

The purpose of this study is to assess the safety of hospital water with regards to their physicochemical qualities. Diseases related to contamination of hospital water constitute a major burden on human health especially nosocomial infections. Excessive amount of physical, chemical and biological parameters accumulated in hospital water is dangerous to the health of patients who access the health facilities and also degrade the infrastructure. Though most of the water samples studied had their parameters within the World Health Organization permissible limit, the few that didn’t conform should be of concern to the government, patients, hospital owners and healthcare providers. Hence, interventions to improve the quality of hospital water in Bayelsa State in order to provide significant health care is necessary.

Consent: Informed consent was gotten from participants.

Ethical Approval: The ethical approval was obtained from the Federal University of Technology Owerri's ethical committee.

Competing interest: Authors have declared that no competing interest exists.

References

1. Food and Agriculture Organization (FAO). Land and Water. United Nations, Geneva, Switzerland. 2022.
2. Cheng J, Corinne J, Watt S, Newbold BK. & Mente A. An ecological quantification of the relationships between water, sanitation and infant, child, and maternal mortality. BMC Environ. Health. 2012; 11(4): 1-8.
3. Umar HO, Okareh OT, Adeleye AO, Orifah MO, Amoo AO, Sabiu N. & Gana SA. Consumers’ perception of municipal water quality in Barnawa Community of Kaduna State, Nigeria. FUDMA J. Sci. 2020; 4(1): 13-23.
4. World Health Organization (WHO) Report: National systems to support drinking-water, Sanitation and hygiene: Global status report. 2019.
5. Jones J. Improving Water Quality in Nigeria. The borgen project. 2019. https://borgenproject.org/water-quality-in-nigeria.
6. United Nations (UN) Sustainable Development Goals (SDG): Goal 6 – Clean Water and Sanitation. Geneva, Switzerland. 2015.
7. World Health Organization (WHO). Drinking-water. World Health Organization, Geneva. 2022. https://www.who.int/news-room/fact-sheets/detail/drinking-water.
8. Angelbeck A, Girolamo A, Ortolano, Francis P, Canonica, Joseph S, Cervia MD. The Hospital Water A Source of Concern for Infections. 2006. Available from: https://www.un.org/sustainabledevelopment/water-and sanitation.
9. Bhalme SP, Dr. Nagarnaik PB. “Analysis Of Drinking Water Of Different Places”- A Review, International Journal of Engineering Research and Applications (IJERA)ISSN: 2248-9622. 2012; 2(3): 3155-3158.
10. Durmishi B. Drinking water quality assessment in Tetova Region. Am J. Environ. 2012; 8(2): 162-169.
11. Panagopoulos A. Process simulation and analysis of high-pressure reverse osmosis (HPRO) in the treatment and utilization of desalination brine (saline wastewater). 2022. Int. J. Energy Res. https://doi.org/10.1002/er.8607.
12. Panagopoulos A. Brine management (saline water & wastewater effluents): sustainable utilization and resource recovery strategy through Minimal and Zero Liquid Discharge (MLD & ZLD) desalination systems. Chem. Eng. Process. Process Intensif. 2022; 176: 108944. https: //doi.org/10.1016/j.cep.2022.108944.
13. Panagopoulos A. & Giannika V. Decarbonized and circular brine management/valorization for water & valuable resource

recovery via minimal/zero liquid discharge (MLD/ZLD) strategies. J. Environ. Manage. 2022; 324 (8): 116239. doi: 10.1016/j.jenvman.2022.116239.

14. Hadzi GY, Essumang DK. & Adjei JK. Distribution and risk assessment of heavy metals in surface water from pristine environments and major mining areas in Ghana. J. Health Pollut. 2015; 5(9): 86-99.

15. World Health Organization (WHO). Guidelines for Drinking-water Quality. Fourth Edition. World Health Organization,Geneva. 2011. https://apps.who.int/iris/bitstream/handle/10665/44584/9789241548151_eng.pdf.

16. World Health Organization (WHO) Guidelines for Drinking Water Quality: Incorporating First Addendum, 4th edn. WHO, Geneva, Switzerland. 2017.

17. Usman J, Nasir AG, Muhammed Y, Muhammad R, Musa S. & Bello AE. Physicochemical analysis of well water utilized in Gusau Metropolis, Zamfara State. Int. J. Sci. Global Sustainability. 2020; 6(2): 73-81.

18. Omoweh DA. The Paradox of Water Crisis and Rural Poverty in the Niger Delta of Nigeria: the Case of Bayelsa State In: Eaux,pauvrete et crises socials (online). Marseille IRD Editions. 2009.

19. Ince M, Bashir D, Oni OOO, Awe EO, Ogbechie V, Korve K, Adeyinka MA, Olufolabo AA, Ofordu F, Kehinde M (2010). Rapid assessment of drinking-water quality in the Federal Republic of Nigeria: country report of the pilot project implementation in 2004-2005. World Health Organization and UNICEF. 2010.

20. World Health Organization (WHO). Guidelines for drinking water quality. Fourth edition incorporating the first and second addenda. 2022.

21. Rim MH. Physicochemical and microbial properties of emergency departments' water at general hospitals. Academia Journal of Scientific Research. 2022; 10(1): 001-004.