REVIEW ON WATER QUALITY FOR SAFE CONSUMPTION IN NIGERIA

A. I. Darma*

I.I.Indabawa*

A.A. Nuhu**

Abstract

Drinking water refers to the water that is safe for human consumption. It should be free from any form of pollution and must meet the requirements of the standards set by the WHO and other organizations. Water quality measures are classified in number of ways; most often are grouped as physical, chemical and biological. The physical characteristics took care of clearity, odour, colour and temperature of the water. Chemical characteristics composed of organic and inorganic matters, for example calcium ion Ca^{2+}, magnesium Mg^{2+} and lead Pb^{++}. It was discovered that the most important chemical constituents are Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, HCO_3, CO_3, OH, PO_4, NO_3 etc. All natural waters contain dissolved ions. The biological parameters are related primarily to the resident aquatic population of microorganisms, impact on water directly. The most important impact is the transmission of diseases by pathogenic organisms in water.It has been shown that water has a wide range of end uses. Therefore, any water intended for consumption should be appropriately tested and ensure that it meets the required standard in order to prevent the effects of those contaminants that are harmful to our health.

Keywords: Consumptions: Health:Standard:Quality: Water

* Department of Biological Sciences, Bayero University, Kano, NIGERIA

** Department of Biological Sciences, Northwest University, Kano, NIGERIA

Introduction

Water is a chemical compound with the chemical formulaH_2O. A water molecule contains one oxygen and two hydrogenatoms connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but it often co-exists on Earth with its solid state, ice, and gaseous state (water vapor or steam). Water also exists in a liquid crystal state near hydrophilic surfaces (Henniker et *al.*, 2011).It covers 71% of the Earth's surface and is vital for all known forms of life (United Nations, 2010).On Earth, 96.5% of the planet's water is found in oceans, 1.7% in groundwater, 1.7% in glaciers and the icecaps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation.Only 2.5% of the Earth's water is freshwater, and 98.8% of that water is in ice and groundwater. Less than 0.3% of all freshwater is in rivers, lakes, and the atmosphere, and an even smaller amount of the Earth's freshwater (0.003%) is contained within biological bodies and manufactured products (Gleick, 1993).

Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of the fresh water used by humans goes to agriculture (Baroni, *et al.*, 2007). Water is an essential element in the maintenance of all forms of life, and most living organisms can survive only for short period without water. This fact has resulted in the development of direct relationship between abundance of water, population density and quality of life (Baroni, *et al.*, 2007).

General significant of water

Water is necessary for all aspects of human and ecosystem survival and health (Postel 1992, Gleick*et al.* 1993). It is used by humans in so many ways. Among which includes; Water is used for drinking. Human body contains from 55% to 78% water, depending on body size (Rhoades *et al.*, 2003). To function properly, the body requires between one and seven liters of water per day to avoid dehydration(Rhoades *et al.*, 2003).The precise amount depends on the level of activity, temperature, humidity, and other factors.Most of this is ingested through foods or beverages other than drinking straight water. It is not clear how much water intake is needed by healthy people, though most advocates agree that approximately 2 liters (6 to 7 glasses) of water daily is the minimum to maintain proper hydration. Medical literature favors a lower consumption,

typically 1 liter of water for an average male, excluding extra requirements due to fluid loss from exercise or warm weather (Rhoades *et al.*, 2003).Humans require water with few impurities. Common impurities include metal salts and oxides, including copper, iron, calcium and lead, and/or harmful bacteria, such as *Vibrio*. Some solutes are acceptable and even desirable for taste enhancement and to provide needed electrolytes (Maton*et al.*, 1993). The single largest (by volume) freshwater resource suitable for drinking is Lake Baikal in Siberia (UNESCO, 2006).

In agriculture, the most important use of water is for irrigation, which is a key component to produce enough food. Irrigation takes up to 90% of water withdrawn in some developing countries and significant proportions in more economically developed countries (United States, 30% of freshwater usage is for irrigation).

The use of water for transportation of materials through rivers and canals as well as the international shipping lanes is an important part of the world economy(Chartres *et al.*, 2010).

Water is widely used in chemical reactions as a solvent or reactant and less commonly as a solute or catalyst. In inorganic reactions, water is a common solvent, dissolving many ionic compounds. In organic reactions, it is not usually used as a reaction solvent, because it does not dissolve the reactants well and it is amphoteric (acidic *and* basic) and Nucleophilic. Nevertheless, these properties are sometimes desirable. Water is also used in chemistry, in the nuclear powerindustry. Water can also be used as a neutron moderator. In most nuclear reactors, water is both a coolant and a moderator.

Humans use water for many recreational purposes, as well as for exercising and for sports. Some of these include swimming, waterskiing, boating, surfing and diving. In addition, some sports, like ice hockey and ice skating, are played on ice. Lakesides, beaches and water parks are popular places for people to go to relax and enjoy recreation. Many find the sound and appearance of flowing water to be calming, and fountains and other water features are popular decorations. Some keep fish and other life in aquariums or ponds for show, fun, and companionship.

Drinking water or portable water

Water fit for human consumption is called drinking water or potablewater (NSDW, 2007).Itcanalsobe defined as the water of sufficient high quality that can be consumed or used with low risk of immediate or long term harm(Wateraid, 2008).Water that is not potable may be

made potable by filtration or distillation, or by a range of other methods.The amount of water for consumption varies with the individual, as it depends on the condition of the subject, the amount of physical exercise, and on the environmental temperature and humidity. An individual's thirst provides a better guide for how much water they require rather than a specific fixed quantity(Wateraid, 2008).In terms of mineral nutrients intake, it is unclear what the drinking water contribution is, However inorganic minerals generally enter surface water and ground water via storm water runoff or through the earth's crust. Treatment processes also lead to the presence of some minerals. Examples include calcium, zinc, manganese, phosphate, and sodium compound (Henson *et al.*, 2010).

Water that is not fit for drinking but is not harmful for humans when used for swimming or bathing is called by various names other than potable or drinking water, and is sometimes called safe water, or "safe for bathing". Chlorine is a skin and mucous membrane irritant that is used to make water safe for bathing or drinking. Its use is highly technical and is usually monitored by government regulations (typically 1 part per million (ppm) for drinking water, and 1–2 ppm of chlorine not yet reacted with impurities for bathing water). Water for bathing may be maintained in satisfactory microbiological condition using chemical disinfectants such as chlorine or ozone or by the use of ultraviolet light (Henson *et al.*, 2010).

The Nigerian standard for drinking water

Nigerian Standard for Drinking Water Quality contains mandatory limits concerning constituents and contaminants of water that are known to be hazardous to health and/or give rise to complaints from consumers. The standard includes a set of procedures and good practices required to meet the mandatory limits.Since water quality issues are health related issues, the Federal Ministry of Health, collaborating with the Standards Organization of Nigeria (the only body responsible for developing National Standards in Nigeria) and working through a technical committee of key stakeholders developed this Standard (NSDW, 2007).

Water quality and contaminants

Water quality refers to the chemical, physical and biological characteristics of water (Nancy *et al.*, 2009). It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose (Johnson *et al.*, 1997). It is most frequently used by reference to a set of standards against which compliance can be assessed

The water quality is assessed in terms of physical, chemical and biological characteristics. Most of the water used or affected by humans can be classified as fresh water because the concentration of dissolved constituents is low. Fresh waters are derived from surface water sources and ground water aquifers (water-bearing rocks). Surface waters tend to be turbid (clear), a property caused by the presence of clays, sands and other height scattering colloidal particles. Ground waters usually have higher total dissolved solids concentrations than surface waters because of mineral pick up from soil and rocks, and many ground waters are used for high concentration of particular ions or elements such as calcium, magnesium, boron and fluoride. Because of their high quality with respect to portability and their minimum treatment requirement, ground waters are therefore preferred sources of water for individual homes and small communities(Johnson *et al.*, 1997).

The physical characteristics of water have to do with the clearity, odour, colour and temperature of the water. The chemical characteristics of water composed of organic and inorganic matters. Specific chemical measures of water quality includes analysis for the presence of specific ions such as Ca^{++}, Mg^{++} and Pb^{++}(Nordell, 1961). Gross chemical measures such as alkalinity and hardness are also used to define water quality. The important chemical constituents are Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, HCO_3, CO_3, OH, PO_4, NO_3 etc.(Nordell, 1961).The biological characteristics of water are related primarily to the resident aquatic population of microorganisms, impact directly on water quality. The most important impact is the transmission of disease by pathogenic organisms in water. The principal organisms found in water may be classified as Protists (higher and lower), plants and animals. All natural waters support biological communities, including many organisms that are harmful to humans. The principal microorganisms of concern in water and waste water include bacteria, fungi, algae, protozoa, worms, rotifers, crustaceans and viruses(Nordell, 1961).

Parameters for portable water quality

Parameters for drinking water quality typically fall under three categories:Physical, Chemical and Biological.

The physical parameters include:

- **Temperature:** Water temperature is affected by air temperature, storm water runoff, groundwater inflows, turbidity and exposure to sunlight. Cool water is generally more palatable than warm water, and temperature will impact on the acceptability of a number

of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems (WHO, 2006).

- **Colour:** Drinking-water should ideally have no visible colour. Colour in drinking-water is usually due to the presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. Colour is also strongly influenced by the presence of 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. (WHO, 2006).Levels of colour below 15 TCU are usually acceptable to consumers, but acceptability may vary (WHO, 2006).
- **Turbidity**:Turbidity is a measure of how particles suspended in water affect water clarity. It is an important indicator of suspended sediment and erosion levels.In other words, turbidity is a measure of the cloudiness of water. It can come from fairly benign sources, such as suspended sediment in the water, or from high levels of disease-causing organisms (EPA, 2004).
- **Taste and Odour**: Taste and odour occurs when many different substances dissolved in water. Humans have developed senses that enable them to evaluate the portability of water by avoiding water that is too salty or putrid. Taste and odour have no unit of measurement and the maximum permissible limit is unobjectionable (EPA, 2004).

Chemical parameters include heavy metals, trace organic compounds, total suspended solids affecting the taste of water, while high concentration of Na^{2+} makes the water taste salty. The recommended dietary amount for Mg^{2+} makes water taste bitter (WHO, 2004). SO_4^{2-} makes water taste unpalatable by decreasing the amount of Ca^{2+}, which is essential for good tasting water. Elements such as Co, Cr, Fe, Mn, Ni, Se, Sn, V and Zn are essential for growth (Henson et al., 2010). Other chemical parameter includes:

- **pH:**The pH level of a drinking water reflects how acidic or not the water is, the pH stands for "potential of hydrogen," referring to the amount of hydrogen found in a substance (in this case, water).pH is measured on a logarithmic scale between 1 and 14 with 1 being extremely Acid (WHO, 2006). However, the EPA recommends that public water systems

maintain pH levels of between 6.5 and 8.5, a good guide for individual well owners (NSDW, 2007).

- **Conductivity**:This is a measure of the capability of a solution such as water in a stream to pass on electric current.It does not identify the specific ions in the water. However, significant increases in the conductivity may be an indicator that polluting discharges have entered the water. (NSDW, 2007).Higher conductivity will result from the presence of various ions including nitrate, phosphate and sodium.Its measured in microomhs per centimeter (µomhs/cm) or microsiemens per centimeter(µS/cm). Distilled water has a conductivity ranging from 0.5-3 µS/cm, while most streams range from 50 to 1500 µS/cm.
- **Total Solids**:Total solid is a measure of the suspended solids in a water body. Thus it is related to both conductivity and turbidity.Total dissolved solids (TDS) are the term used to describe the inorganic salts and small amounts of organic matter present in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions (WHO, 2003). According to the WHO, TDS in drinking-water originate from natural sources, sewage, urban runoff and industrial wastewater. Salts used for road de-icing in some countries may also contribute to the TDS content of drinking-water. Concentrations of TDS in water vary considerably in different geological regions owing to differences in the solubilities of minerals.
- Dissolved Oxygen (DO):The DO concentration is the mass of the oxygen gas present in milligrams per liter of water.Milligrams per liter (mg/L) can also be expressed as parts per million (Thurman, 2007). Dissolved oxygen is oxygen gas molecules (O_2) present in the water. Plants and animals cannot directly use the oxygen that is part of the water molecule (H_2O), instead of depending on dissolved oxygen for respiration. Oxygen enters streams from the surrounding air and as a product of photosynthesis from aquatic plants.Human factors that affect dissolved oxygen in streams include addition of oxygen consuming organic wastes such as sewage, addition of nutrients, changing the flow of water, raising the water temperature, and the addition of chemical (WHO, 2006).

- **Hardness:**Water hardness is the traditional measure of the capacity of water to react with soap, hard water requiring considerably more soap to produce lather. It is not caused by a single substance but by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations (e.g. aluminium, barium, iron, manganese and zinc) also contribute. Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per liter.Hardness does not pose a health risk and is not regulated by state or federal agencies. In fact, calcium and magnesium in drinking water can help ensure you get the average daily requirements for these minerals in your diet.Hardness often causes aesthetic problems, such as an alkali taste to the water that makes coffee taste bitter (WHO, 2003).

The biological parameters include primarily the characteristics of water in relationto the resident aquatic population of microorganisms, impact directly on water quality(WHO, 2003). The most important impact is the transmission of disease by pathogenic organisms in water. The principal organisms found in water may be classified as protists (higher and lower), plants and animals. All natural waters support biological communities, including many organisms that are harmful to humans.

- The principal microorganisms of concern in water and waste water include bacteria, fungi, algae, protozoa, worms, rotifers, crustaceans and viruses.The greatest risk from microbes in water is associated with consumption of drinking-water that is contaminated with human and animal excreta, although other sources and routes of exposure may also be significant (WHO, 2006).
- Micro-organisms and waterborne pathogens enter rivers and lakes either naturally or via the release of untreated or partially treated sewage.Bilharzia and malaria are other waterborne diseases that persist in the tropical regions. Drinking and bathing water polluted with Escherichia coli and coliform bacteria can easily cause infections (NSDW, 2007).The human health effects caused by waterborne transmission vary in severity from mild gastroenteritis to severe and sometimes fatal diarrhoea, dysentery, hepatitis and typhoid fever (WHO, 2003).Contaminated water can be the source of large outbreaks of disease, including cholera, dysentery and cryptosporidiosis.

- Most waterborne pathogens are introduced into drinking-water supplies in human or animal faeces.However, *Legionella*, atypical mycobacteria, *Burkholderiapseudomallei*and *Naegleriafowleri*are environmental organisms that can grow in water and soil. Besides ingestion, other routes of transmission can include inhalation, leading to infections of the respiratory tract (e.g., *Legionella*, atypical mycobacteria), and contact, leading to infections at sites as diverse as the skin and brain (e.g., *Naegleriafowleri*, *Burkholderiapseudomallei*).Of all the waterborne pathogens, the helminth,*Dracunculusmedinensis*is unique in that it is the only pathogen that is solely transmitted through drinkingwater (WHO, 2006).

Water-Borne Infections

The pathogens that may be transmitted through contaminated drinking-water are diverse. Water temperatures and nutrient conditions present in drinking-water distribution systems are highly unlikely to support the growth of these organisms (George *et al.*, 2001).The presence of *E. coli* (or, alternatively, thermotolerant coliforms) provides evidenceof recent faecal contamination, and detection should lead to consideration of further action, which could include further sampling and investigation of potential sources such as inadequate treatment or breaches in distribution system integrity.(Grabow*et al.*, 2001).Intestinal enterococci are a subgroup of the larger group of organisms defined as faecal streptococci, comprising species of the genus *Streptococcus*. These bacteria are Gram-positive and relatively tolerant of sodium chloride and alkaline pH levels. In addition, they have been used to test water quality after repairs to distribution systems or after new mains have been laid. The presence of intestinal enterococci provides evidence of recent faecal contamination (Ashbolt*et al.*, 2001).

For pathogens transmitted by the faecal–oral route, drinking-water is only one vehicle of transmission. Contamination of food, hands, utensils and clothing can also play a role, particularly when domestic sanitation and hygiene are poor. Improvements in the quality, availability of water, and in general hygiene are all important in reducing faecal-oral disease transmission.*Dracunculusmedinensis*commonly known as guinea worm belongs to the phylum nematode and is the only nematode associated with significant transmission by drinking water (Cairncross*et al.*, 2002). Drinking water containing *Cyclops* is the only source of infection with *Dracunculussp*. The disease occurs in rural areas where piped water supplies are not available

(Hopkins *et al.*, 1991). Prevention of this disease can be through the provision of boreholes and safe wells. Wells should be surrounded by cement. Bathing and washing in these waters should be avoided. Other control measures include filtration of water carrying infectious *dracunculus* larvae through a fine mesh cloth or by treating drinking water with chlorine to make *Cyclops*spp inactive (Cairncross*et al.*, 2002).

Cyanobacteria are photosynthetic bacteria that share some properties with algae.Some of this species form surface blooms or scums, while others stay mixed in the water column or are bottom dwelling (benthic)**.** Many cyanobacteria produce potent toxins(Chorus *et al.*, 1999). Each toxin has specific properties, with distinct concerns including liver damage, neurotoxicity and tumour promotion.Cyanobacteria do not multiply in the human body and hence are not infectious (Chorus *et al.*, 1999).Depending on the species, this may result in greenish discoloration of water due to a high density of suspended cells and, in some cases, the formation of surface scums. Such cell accumulations may lead to high toxin concentrations (Lahti *et al.*, 2001).Acute symptoms reported after exposure includesgastrointestinal disorders, fever and irritations of the skin, ears, eyes, throat and respiratory tract(Chorus *et al.*, 1999).

Conclusion

From the literatures above, it was found that water is being in abundant supply, and has special characteristics. Its quality is defined in terms of those characteristics. Therefore its quality is assessed in terms of physical, chemical and biological characteristics. Most of the water used or affected by humans can be classified as fresh water because the concentration of dissolved constituents is low. Somecriteria were set for it to be safely consumed by humans throughout their lifetime. These criteria usually depend on the potential of different methods of raw water treatment to reduce the concentration of water contaminants to the level set. It was found that drinking water treatment range from simple physical treatment and disinfection to intensive physical and chemical treatment.Conclusively, it has been shown that water has a wide range of end uses associated it. Therefore, any water intended for consumption should be appropriately tested and ensure that it meets the required standard in order to prevent the effects of those contaminants that are harmful to our health.

References

Anadu P, (1999):*Water pollution,consequences, prevention and education*. Series no. 2 22-27pp.

Ashbolt NJ, Grabow WOK, Snozzi M (2001): Indicators of microbial water quality. In: Fewtrell L, Bartram J, eds. *Water quality: Guidelines, standards and health – Assessment of risk and risk management for water-related infectious disease*. WHO Water Series. London, IWA Publishing, pp. 289–315.

Backer L.C (2002):Cyanobacterial harmful algal blooms (CyanoHABs): Developing a public health response. *Lake and Reservoir Management*, 18:20–31.

Baroni, L.; Cenci, L.; Tettamanti, M.; Berati, M. (2007): *Evaluating the environmental impact of various dietary patterns combined with different food production systems*.European Journal of Clinical Nutrition61 (2): 279–286. doi:10.1038/sj.ejcn.1602522. PMID 17035955.

Ben-Naimet. al., Ariel (2011). *Alice's Adventures in Water-land*. Singapore.

Braun, Charles L.; Sergei N. Smirnov (1993):"Why is water blue?".*J. Chem. Educ.***70** (8): 612.:10.1021/ed070p612.

Cairncross S, Muller R, Zagaria N (2002): *Dracunculiasis (guinea worm disease) and the eradication initiative*.Clinical Microbiology Reviews, 15:223–246.

Campbell, Neil A.; Brad Williamson; Robin J. Heyden (2006):*Biology: Exploring Life*. Boston, Massachusetts: Pearson Prentice Hall. ISBN 0-13-250882-6.

Chartres, C. and Varma, S.(2010):*Out of water. From Abundance to Scarcity and How to Solve the World's Water Problems* FT Press (USA),

Chorus I, Bartram J, eds. (1999):*Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management*. Published by E & FN Spon, London, on behalf of the World Health Organization, Geneva.

Clerk R.B., (1997): *Marine Pollution*, 4th edition Calerendo Press, Oxford.

Eagleman R. and P. LeRoy, (1993): Sustaining Water: Population and the future of Renewable Supplies. *Population Action In ternational*, Washinton D.C.

Encyclopedia International (1985):*Environmental Pollution*. New Yolk, U.S.A. Vol. 14;494

Falkenmark, M and G. Lindh (1974): "*Impact of Water Resources on Population*". Submitted by the Swedish Delegation to the UN World Population Conference, Burcharest, 19-30 August.

Foster J. (1991):*Environmental pollution*. Oxford University press, Oxford.

George I et al. (2001):*Use of rapid enzymatic assays to study the distribution of faecal coliforms in the Seine river* (France). Water Science and Technology, 43:77–80.

Gleick P.H (1996):*In Press Meeting Basic Needs; Minimum water Requirements for Human Activities:* "In Preparation, pacific Institute for studies in Development, Environmental and Security, Oakland, California.

Gleick, P.H(ed). (1993):*Water in Crises; A Guide to the World's Fresh Water Resources*, Oxford University Press.

Gleick, P.H. (2010):*"Peak Water"*. Proceedings National Academy of Science (National Academy of Science) 107 (125): 11155–11162.

Gleick, P.H., ed. (1993):Water in Crisis: A Guide to the World's Freshwater Resources. Oxford University Press. p. 13, Table 2.1 "Water reserves on the earth".

Grabow WOK (1996):*Waterborne diseases*: Update on water quality assessment and control. *Water SA*, 22:193–202.

Henniker J.C. (2011). *"The Depth of the Surface Zone of a Liquid"*. (Reviews of modern physics) 21 (2): 322-341. doi:10.1103/RevModPhys.21.322.Pollack, Gerald.

Henson S.A, Sermiento J.L, Dunne J.P, Bopp L. Lima, Doney S.C, and John J., Beaulieu C. (2010): *"Detection of anthropogenic climate change in satellite records of ocean chlorophyll and productivity"*. Biogeosciences7 (2): 621-640 doi: 10.5194/bg-7-621-2010.

Hopkins DR, Ruiz-Tiben E (1991):*Strategies for dracunculiasis eradication*. Bulletin of the World Health Organization, 69:533–540.

Johnson, D.L., S.H. Ambrose, T.J. Bassett, M.L. Bowen, D.E. Crummey, J.S. Isaacson, D.N. Johnson, P. Lamb, M. Saul, and A.E. Winter-Nelson (1997): *"Meanings of environmental terms."*Journal of Environmental Quality.26:581-589:

Kotz, J. C., Treichel, P., & Weaver, G. C. (2005):*Chemistry & Chemical Reactivity*. Thomson Brooks/Cole. ISBN 0-534-39597-X.

Kulshreshtha, S.N (1998): "A Global Outlook for Water Resources to the Year 2025". *Water Resources Management***12** (3): 167–184. doi:10.1023/A:1007957229865.

Lahti K et al. (2001): *Occurrence of microcystins in raw water sources and treated drinking water of Finnish waterworks.*Water Science and Technology, 43:225–228.

Maton, Anthea; Jean Hopkins, Charles William McLaughlin, Susan Johnson, MaryannaQuon Warner, David LaHart, Jill D. Wright (1993):*Human Biology and Health*. Englewood Cliffs, New Jersey, USA: Prentice Hall. ISBN 0-13-981176-1. OCLC 32308337.

McGowan W (2000):Water *processing: residential, commercial, light-industrial,* 3rd edition. Lisle, IL, Water Quality Association.

Molden, D. (Ed).(2007):*Water for food, Water for life: A Comprehensive Assessment of Water Management in Agriculture.*Earthscan/IWMI, 2007.

Nancy, Diersing (2009):*"Water Quality: Frequently Asked Questions."* Florida Brooks National Marine Sanctuary, Key West, FL

Neri L.C. et al. (1985):*Magnesium and certain other elements and cardiovascular disease.*Science of the Total Environment, 42:49-75.

Noakes TD, Goodwin N, Rayner BL, Branken T, Taylor RK (2005): "Water intoxication: a possible complication during endurance exercise,Wilderness Environ Med16 (4): 221–7. doi:10.1580/1080-6032(2005)16[221:WIAPCD]2.0.CO;2. PMID 16366205.

Noakes TD, Goodwin N, Rayner BL, *et al.* (1985):*"Water intoxication: a possible complication during endurance exercise". Med Sci Sports Exerc***17** (3): 370–375. PMID 4021781.

NordellEskel (1961):*Industrial Water Supply*. Reinhold publication Corporation. www.books.google.com/watertreatment.

NSDW, (2007):*Nigerian Standard for Drinking Water Quality.* Nigerian Industrial Standard, SON Governing Council, 13/14 Victoria Arobiek Street, Lekki, Lagos, Nigeria.

Ravindranath, Nijavalli H.; Jayant A. Sathaye (2002):*Climate Change and Developing Countries*. Springer. ISBN 1-4020-0104-5. OCLC 231965991.

Rhoades RA, Tanner GA (2003):*Medical Physiology* (2nd ed.). Baltimore: Lippincott Williams & Wilkins. ISBN 0-7817-1936-4. OCLC 50554808.

Shiklomanov I.A (2000): *Appraisal and Assessment of Water Resources,* water international 25 (1) 11-32.

Shiklomanov V.I., (1993): "*World Fresh Water Resources*". Oxford University Press, New Yolk, pp 13-24.

Sink R.L (1996):*Municipal and Rural Sanitation.* Oxford University press, Oxford.

Thurman, H.V. (2007):*Introductory Oceanography.* Academic Internet Publishers. ISBN 978-1 4288-3314-2.

UNEP International Environment (2002):*Environmentally Sound Technology for Wastewater and Stormwater Management: An International Source Book*. IWA Publishing. ISBN184339 008-6. OCLC 49204666.

Unesco (2006):*Water: a shared responsibility*. Berghahn Books. p. 125. ISBN 1-84545-177-5.

United Nations Press Release (2007):World population will increase by 2.5 billion by 2050

WHO (2003):*Chloride in drinking-water. Background document for preparation ofWHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/3).

WHO (2003):*Copper in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/88).

WHO (2003):*Hardness in drinking-water. Background document for preparation ofWHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/6).

WHO (2003):*Iron in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/8).

WHO (2003):*Manganese in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/104).

WHO (2003):*Nitrate and nitrite in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/56).

WHO (2003) *Sodium in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/03.04/15).

WHO (2003):*Total dissolved solids in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization(WHO/SDE/WSH/03.04/16).

WHO (2006): Guidelines for Drinking Water Quality. World Health Organisation, Geneva. www.who.int.com. Retrieved 5/09/2013.

WHO (2008):*Safe Water and Global Health"*. World Health Organization, Geneva. www.who.int.com. Retrieved 7/09/2013.