

Research Article

ASSESSMENT OF NATURAL AND ANTHROPOGENIC FACTORS OF SAFE WATER ACCESSIBILITY IN DEVELOPING COUNTRIES

*OYENIYI, Samson Oluseyi

Department of Urban and Regional Planning, Faculty of Environmental Studies, Osun State College of Technology, Esa-Oke, Nigeria

Received 16th February 2020; Accepted 20th March 2020; Published online 30th April 2020

ABSTRACT

Poor access to safe water has aggravated socio-economic, psychological and health problems in human societies; it has resulted in stress, perturbation, sicknesses and death across times and regions of the world. This work reviews the factors of safe water accessibility in human society and exposes unacknowledged natural and anthropogenic factors of water accessibility. It concludes that the principal factor of water accessibility is value. Safe water is not accessible in many places despite its essentialness because it's not valued enough at the levels of leadership as it's expected. Consequently, the work recommends that commensurate values should be accorded safe water provision and adequate payment of all forms of 'prices' to ensure sustainable provision of safe water in human societies. The work will be of immense benefits to policy makers, international organizations, urban planners and the general public.

Keywords: Safe Drinking Water, Natural and Anthropogenic Factors, Value of Water, Economy and Humanity

INTRODUCTION

Access to safe drinking water is measured by the percentage of the population having access to and using improved drinking water sources. Improved drinking water sources should, but do not always provide safe drinking water, and they include: piped household water connections, public standpipes, boreholes, protected hand-dug-wells, protected springs and rainwater collection while unprotected sources are: unprotected dug wells, unprotected springs, surface water (river, dam, lake, pond, stream, canal, irrigation channels, vendor-provided water (cart with small tank/drum, tanker truck), bottled water, tanker truck water (Water and Sanitation Summary Sheet, WASH, 2012). Access to safe water supply is a basic human need which must be satisfied with adequate quantities that comply with minimum health standards Alihaji and Adamu (2017). Inadequate access to safe drinking water is one of the most serious challenges of humanity and has aggravated socio-economic, psychological and health problems. The situation is worsened by ever-increasing urban population growth, poor sanitation recessed economy and a whole lot of other silent factors explicated in this work.

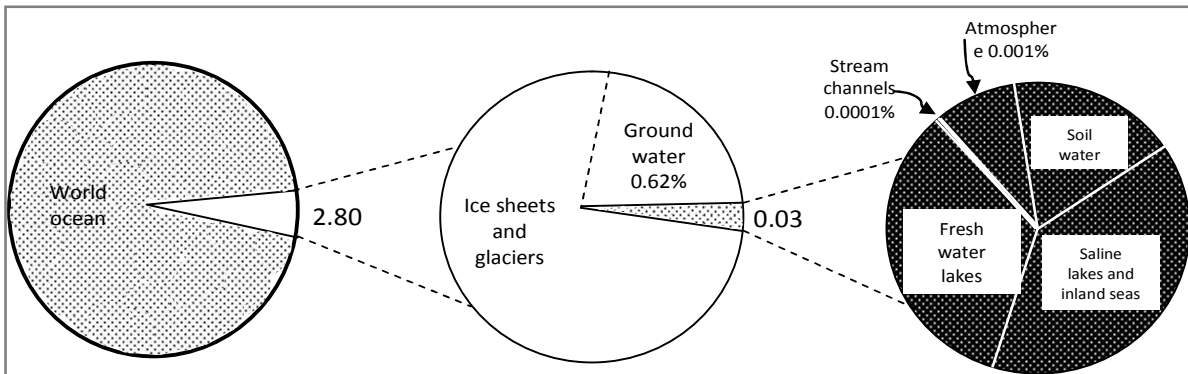
Review of Literature

Humanity needs for water cannot be overstated; one is therefore not surprised at the location of great civilization on the banks of the Earth's waterways. According to Santra (2013), the planet earth should be described as Aqua rather than Terra because of its characteristics abundance of water. But 97.2% of this water lies in the salty ocean, 2.15% in frozen ice, only three percent of the world's water supply is fresh, of that three percent, less than one percent is accessible for human consumption (World Wildlife Fund, 2016). Santra (2013) further stated that only 0.65% remains as fresh water either on land or as ground water which is again not evenly distributed (See Fig.1). To worsen the situation, human population is increasing at an astronomical rate without corresponding increase in fresh water quantity and accessibility.

Yet, water ensures humankind's survival and prosperity; even human body needs between 2 liters of water each day or eight glasses of water daily to survive Rachel *et al* (2008). According to offline Advance Learners' Dictionary, to access is to obtain, or retrieve from storage, or make use of or take advantage of something. Miriam Webster online dictionary sees 'access' as permission, liberty or ability or freedom to obtain or make use of something. The concept of 'access' as opined by Jesse and Nancy (2003) is the ability to benefit from resources; who benefits? How? and when? who enjoys or uses what? who does not? in what circumstances?. In the authors' concept of 'mechanism of access', some structural and relational mechanism of access was identified, since access to resources are facilitated and hindered by certain socio-cultural, political and economic factors, these factors include access to capital, knowledge, technology, authority, socio-cultural identity, labour and market. Spatio-temporal variability in water accessibility is also mediated by climatic factors of location, bulky nature of water, the capital intensity and fix nature of water infrastructure, the economics of scale relating to water infrastructure, Peoples' Willingness to Pay, (WTP) and Willingness to Accept (WTA) were mentioned by Hanemann 'Economic Conception of Water' (Undated) and Abubakar (2016) also highlighted some other factor affecting water accessibility, which includes urbanization and unsustainable water consumption practices, inadequate monitoring of water quality, bacteriological contamination during distribution, poor water quality, poor governance and stakeholders' involvement, population imbalance, migration, technical inefficiencies and unreliability, over-dependency or government finance, inadequate technical skilled personnel. Jideonwo (2014) concluded that the challenges of public water utilities and public water supply systems have technical, social, economic, legal, institutional and environmental dimensions. As reported by World Health Organization (WHO, 2019) water is accessible when an individual is availed a volume of at least 50 litres per day, but a technical report by Cross River State (a state Nigeria) Technical Unit (CRSTU) (2009) defined access to safe water as the availability of potable water of at least 30 litres per person per day, located within or at 250 - 500 meters of every household.

*Corresponding Author: OYENIYI, Samson Oluseyi,
Department of Urban and Regional Planning, Faculty of Environmental Studies, Osun State College of Technology, Esa-Oke, Nigeria.

	Volume, Km ³	Mass, g
Sea water	1.37×10^9	1.41×10^{24}
Fresh water lakes	1.3×10^5	1.3×10^{20}
Saline lakes and inland seas	1.0×10^5	1.0×10^{20}
Rivers	1.3×10^3	1.3×10^{18}
Ground water	8.4×10^6	8.4×10^{21}
Icecaps	2.9×10^7	2.9×10^{22}
Water vapour	1.3×10^4	1.3×10^{19}



Source: Santra (2013)

Fig. 1. World water distribution

Odafivwotu and Abel (2014) described access to potable water supply as 'having access to safe drinking water with microbial, chemical and physical characteristics that meet the WHO guidelines. UNPD (2010) asserted that water is accessible if it can be acquired within a convenient distance of at least 200 meters where it is not present within residence, beyond that distance, water is inaccessible. As reported by John Vidal an environmental editor in The Guardian of 30 August, (2012), United Nation Environmental Programme (UNEP) over 400 million Africans now live in water scarce countries, 300 million people still do not have reasonable access to drinking water. According to the report, African government gave cacophony of reasons for their inability to provide water in World Water Week held in Stockholm. Their reasons includes but not limited to; lack of necessary laws, no one to champion the course of safe water provision, lack of human capacity, inadequate private sector and civil society involvement, instability, inadequate collection of revenue and donor fund, no infrastructure, slowness in mobilizing financing. Alihaji *et al* (2017) citing World Health Organization (WHO, 2012) stated that, almost 137 million people in urban populations across the world have no access to safe drinking water, and more than 600 million urban dwellers do not have adequate sanitation. Nyarko *et al* (2010) opined that poor planning and budgeting for, inadequate understanding of actual cost of water provision, cost of capital investment in water, inadequate information about initial cost of hardware and software, human training, using, operating and maintaining a system under community management, inadequate constant collection of information on minor maintenance cost of the system, post construction support as well as system rehabilitation and replacement. Okon and Njoku (2017) pointed to cost of water, increasing population, regional imbalances in supply and unavailability of pipe-borne water connections, intermittent supply, and far distance to water source and distribution lapses as impediment to citizen's access to safe water. United Nations' Water Accessibility Report of (2019) reveals increasing water use worldwide by about 1% per year since 1980s, as a result of population growth, socio-economic development and changing consumption patterns. The report further stated that global water demand is expected to continue increasing at a similar rate until 2050, increasing to 20 to 30% above the current level of water use, this has complicated the exiting water accessibility.

The Unacknowledged Water Accessibility Factors

- Access to Capital:** Availability of capital can guaranty access to water and other resources. Capital is a powerful weapon; it helps to gain social recognition and sustains it, it can assure maintenance and control of access to water resources, it can also be used to pay expected dues and rents or rates, it can be used to buy and to maintain influence and give undue advantage to whoever has it to negotiate for, gain, enjoy maintain and sustain control of water sources. It could be used to procure best water provision related gargets and equipment as well as maintain their continuous functionality. Access to capital creates good opportunity to engage and maintain the services of best hands in human resource operating water related schemes. With access to adequate capital, water resources could be made available in the most unlikely places; desert areas, places of rugged relief or salty or highly polluted water.
- Access to Knowledge:** Access to water and other resources may transcend material and financial wealth. It may proceed to discursive, scientific, technical, ideological, spiritual and socio-cultural ream. Knowledge may present opportunities to misinform, deceive, lie to or brainwash others to the advantage of the possessor of the said knowledge. Knowledge is power and power corrupts is a popular statement in politics; It could be used to suppress, oppress, subjugate, influence, gain and maintain control over essential water resources that is needed daily by all and sundry. Absolute power corrupts absolutely; the more power one possesses, the more influence and control he/she brings to bear. Such knowledge and power may be used to influence establishment, location, size of water scheme, the contractor to handle the construction, the distribution of safe water and even water rate to be paid.
- Access to Technology:** Raw water is mostly consumed globally, and this valuable treasure is not the type laying open on the earth surface, a measure of technology is needed to access it. Access to necessary technology like drilling and pumping machines as well as electricity to power them may ensure unhindered access to safe water. The better the available technology, the better the access to safe water. A rope and bucket water drawer used to draw water from hand-dug-well is a form of technology; drilling

borehole involves a better technology, a massive water scheme is a level of application of available technology and a water recycling scheme is equally a form of higher level technological application. Access to good technology made water treatment possible and the better the technology the safer the water. A simple but protected wire nest or concrete fence around water source may improve water safety and guarantee control of water source.

- d) Access to Authority:** Resources are being competed for but people in position of authority are in charge of allocation of resources either directly or otherwise. By virtue of their position, they reside in special palaces (state houses), a place of all sufficiency at the expense of the state. They do transfer these privileges to people that have access to them. They do influence the location of water schemes, sizes and coverage of supplies; they may have priority areas where scheme will be located, cover and supplied, this locations may be selected they can be selective along economic, political and social religions and ethnic lines, they can interfere in regularity or consistency of water supply. Communities with good representation at the helm of affairs may enjoy better access to water than others. Special attention could also be paid to peoples in position of authorities' place of birth or in-law or friends.
- e) Access Through Social and Cultural Identity:** Social identity for royal families, chives, elderly, respected members of community, ethnic and religious status, could be considered and people having status as such could be accorded first place in water point location and consequent privileged access. In rural areas, public water points provided by government is always situated in proximity to king palaces as a result of the presence of the king and his royal family as well as other influential member of the community, worship centers especially mosques, due to the higher need of water in relation to the nature of warship as well as influence of religions in general. City/town / community centers also always enjoy priority in water point location because of centrality, culture, social and economic roles played by those centers. In most cultures, the elderly are accorded first place when people needs to queue, children and women may also be considered first in most places.
- f) Right Based Access:** Access sanctioned by law, custom or tradition landownership, leasehold can mediate access to water sources. Ownership of land and everything therein can grant people unequal access to water sources. Landowners may allow or disallow residents to come in to their houses/compounds/properties and access water. Jesse and Nancy (2003) opined that property right holders retains the right and can sanctions, they can apply the associated enforcements mechanisms on any trespasser. Fetching water from certain sources may be prohibited by culture or tradition; such sources may include traditional worship centers, an abode of a gods or goddess, where water source are considered sacred. Traditional and religious leaders may claim right of the water sources and hinder people from accessing water at such sources.
- g) Right by Theft Access:** Access can be gained by forceful or illegal means. From time immemorial water has been a source of tension and a factor in conflicts that start for other reasons including but not limited to lack of water, military actions, political crises, development actions and population expansion (hydrofinity.com), water source disputes, a quest for undue advantage to water sources. In (1997), a highly contended water reserve straddling Kyrgyzstan and Uzbekistan borders leads to the deployment of 130,000 Uzbekistani soldiers to stand guard on the Toktogul reservoir. In the year (2000), drought-stricken monkeys attack a Kenyan village for water-tanker access leaving eight monkeys dead and ten Kenyans wounded, in 2001, Macedonians fight with Albanians in village of Radusa over control of the water reservoir that supplies the nation's capital (worldwaterreserve.com). In the Holy Bible, (Genesis chapter 26 verse12-22 established the idea of 'Right by Theft' in water accessibility. Possession of weapons can aid illegal possession and dispossession of safe water sources. Intellectual strength may alter the natural distribution of water access, for instance; 'land grabbers', community leaders, royal family or even government may dispossess people of their properties including water sources or potential water sources against the peoples' wills.
- h) Climatic Factors:** Rainfall and temperature distribution do influence water distribution and its consequent accessibility (seasonal variation). Climatic variability and instability potent possible unreliability in water accessibility. Adequate and relatively evenly spread of rainfall in the months of raining seasons may guarantee accessibility of rain water known as one of the improved water sources. Excessive rainfall do result in flood and destructive erosion which seeps into existing drinking water sources and pollute them Omotoso and Oyeniyi (2015). People in the tropics suffer when season changes and water sources dry and people need to scoop water from brooks and other reliable and unsafe drinking water sources.
- i) Location on the Planet Earth:** Residing in desert areas, areas of rugged relief and coastal areas characterized by swamps or salty water could limit residents' accessibility to safe water. Water is life saving and the most desired resource in places after air. Residing in poverty ridden countries/cities, overpopulated settlements where water system is non functional, inefficient or overstressed living environment like blighted areas, slums/shanty or other informal environments could limit water accessibility while people living in planned cities or government reserved areas has better access to safe drinking water.
- j) Bulky Nature of Water:** Water is heavy, therefore, good quantity is relatively difficult to transport over a long distance like say hundreds of kilometers away. Addressing the imbalance in access through transportation is extremely costly, it can be more easily store but a lot of resources may be needed to move and store adequate quantity to last for a while in places of shortage. Caring water over a long distance is an issue, little wonder therefore, the farther the water source, the lesser the accessibility since man can't carry enough for himself for a day over a kilometer distance.
- k) The Cost of Water Infrastructure:** Water infrastructure is capital intensive and may take longer time to be provided compare to other utilities. The up-front investments in procurement of pumps and water treatment equipments, the cost and processes of damming, diverting water and lying of different categories of pipes, provision of water storage facilities; maintaining and ensuring safe water supply and sustainability of such infrastructure is also not cheap.
- l) The Fix Nature of Water Infrastructure:** Investment or capital assets used in water provision and supply are fixed and non malleable; hydro-power schemes, water reservoirs pulping stations, network designs and dimensions, network of laid pipes, trenches and many more. The assets are not easily used for other purposes. Equally, unlike electricity infrastructure (transformer, cables etc.) only a few of them can be moved to other locations or employed for other uses.
- m) The Economy of Scale Relating to Water Infrastructure:** Water infrastructural provision is not a priority for politicians since people can opt for alternatives in self water provision. Other social amenities or and infrastructural facilities like road, schools, medical and recreational infrastructures take priority over water infrastructure. Besides, water is considered as a social good in

many places, most times, providers don't break even; there is no or at most low return on investment and government or other providers are discouraged from investing more on safe water infrastructural provision.

- n) Willingness To Pay, (WTP) and Willingness To Accept (WTA):** What resources time and or financial resources people are willing to part with in exchange for safe water at household, community, local, state and national levels. Once people are satisfied with status quo and accept the current water accessibility situation, improvement may not come too soon. If people demand and agitate for better access and are ready to do the needful, safe water access will increase. Where and when government at all levels as well as other providers are willing and ready to invest more on water scheme and ensure the necessary maintenance and the people are willing to pay for the good service delivery, good accessibility to safe water will definitely ensue.
- o) Water Schemes' Poor Quality of Service:** Water schemes do not perform to their optimum in most places across the globe due to poor and inadequate power supply, broken-down equipments, unbearable operational cost, corruption, poor maintenance of equipment, unmetered supply and unremitted water rates (United Nations Development Programme DUNPD, 2010). Consequently, the populace do not have the expected service delivery and are denied access to safe water; expected places are not covered, water is being rationed, it is only available in a few hours and only in a few days of the week in developing countries.
- p) Government Policies, programs and Initiatives:** Policies, programs and initiatives of constituted authorities at a time influence water accessibility. Government disposition and commitment will reflect on her sincere intention to improve water accessibility. Beyond this, implementation and follow-up of the said policies and programs is more important, the sincerity of purpose, the involvement of residents, collaboration with Public Private Partnership initiatives (PPP) and involvement of private sector as well as all other stakeholders.
- q) Water related Laws:** Overlapping responsibilities in water provision especially resulted in neglect and poor access results, since welfare of everyone's life is no one's responsibility. In the constitution of Federal Republic Nigeria for instance, water provision is in residual list, meaning that federal, state and local governments are saddled with the responsibility of safe water provision. State governments in most cases lack the capacity not to mention local governments.
- r) Cost Recovery in Water Provision:** Public stand pipes are many and they are not metered, home connections are not always properly priced and fund in terms of rates are not remitted, hence, financing water provision becomes government sole responsibility and water is considered 'a common pool resource, a social and economic good' Nwankwoala (2010). Some invade water rate payment, some broken water pipes and scoop water from broken pipes, treated water is wasted in large quantity.
- s) Poor Maintenance:** International Organizations like United States Agency of International Development (USAID), World Health Organization (WHO), United Nations International Children's Emergency Fund (UNICEF), Water Aid Council (WAC), European Union (EU), NGOs and many others in tackling have done a lot in provision of safe water accessibility in developing countries. Many national and international organizations and religious bodies sink boreholes in selected localities, this have gone a long way in safe water provision, only that the efforts are greeted with poor maintenance plans, so, the scheme do serve for a short time.
- t) Urbanization, Population Dislocation and Industrialization:** Resources, services and amenities are becoming grossly inadequate in the ever growing settlements especially in developing countries. Unreasonably crowded cities do not enjoy expected access to water, water is being competed for by the residents and the demand is increasing daily resulting in long queues and quarrels at few available water points. Industrialization is a concomitant of urbanization; ground water that urban residents do result to has become seriously polluted. Industrial pollution by heavy metals and trace elements, various organic compound and inorganic elements, gasoline, degreasing, dry-cleaning solvent volatile organic chemicals have polluted our drinking water in many places developing countries' cities Ibiang et al, (2019) Vidal et al (2000), Diagonanolin et al (2004) and John and Mark (2003).
- u) Inadequate Policy, Planning and Forecasting:** The rate and level at which the world is becoming urbanized is not expected; policies and planning efforts are unable to cope or catch-up with the speed. Robust policies are poorly and untimely executed. There is little or no maintenance plan for water provision projects, schemes especially boreholes Oyeniyi (2019). Policies and plans are top-down in approach; policy makers do not carry out adequate consultation and people are not carried along therefore, residents do not embrace presumed policies and plans most times. Rate of water demand is higher than planning and forecasting, not only that, the demand keeps increasing per time by the dictates of population and urbanization, hence, poor access results.
- v) Poor Water Pricing and Service Delivery by Water Corporations:** It is difficult to put price on a good that does not have market price because goods signal how much it's worth to an average consumer Nwankwoala (2010). Ghazani et al (2009) reported that water is an essential resource that is most squandered because of poor pricing. Water provision is almost free in developing countries because public stand pipes are the most commonly used and are not billed. Poor budgetary allocation, corruption, old and dilapidated equipment, poor coverage and monitoring among other issues do not allow water corporations to raise adequate fund capable of ensuring optimum performance and maintain good and reliable service delivery.
- w) Inappropriate Land Uses:** Water accessibility in unplanned settlements is not always adequate because water is unnecessarily polluted from badly sited septic tanks, dead relatives are buried close to groundwater sources especially wells Omotoso and Oyeniyi (2015), local industries also do come up with pollutants, oil is split around wells, grease and laundry materials find their ways into drinking water sources, water from doubtful sources are badly treated and used; the residue from treated water constitute another form of dirt in drinking water. Afrey (2014) stated that untamed erosion and water logging and destructive characteristics of unplanned environment, contributes immensely to poor water accessibility because they seep into drinking water sources and pollute them. Unplanned settlements give no adequate room/space for planned source of reliable and safe water.
- x) Relief:** The differences in water availability and accessibility between high altitude and valleys or water basins are clear. Water table do differ, moving water from one point to another is also different. The cost of accessing water is not the same; possibly, water quality sourced from the high altitude may differ from that of valleys, accessibility could be easier, cheaper and better at lowland areas and costlier in highland areas. Even in urban centers, rugged reliefs are technically avoided while laying pipes for water supply, because, water corporations may lack capacity to pump water uphill as discovered by Oyeniyi (2019), hence,

people residing in such places has lesser access to cheap safe water.

- y) **Type and Nature of and Aquifer:** Safe water accessibility depends on nature and natural underground water reservoir. Aquifers are bodies of rock containing water. The three main underground formation types are hard crystalline, consolidated and sedimentary rocks. Hard crystalline has gneisses, granites, quartzite schist and possibly certain forms of volcanic materials. This type of formation do not have much aquifer, water is only present in fractures. Aquifers in such hard rocks are localized and do not produce much water. If volcanic activity is present, water from such sources may not be acceptable; it may contain some natural pollutants in excess, boron and fluoride are good examples. In contrast, consolidated sedimentary formation may be thick and most times extensive, they are high water yielding. Sizes of grains determine porosity and permeability, clay and silt are less water productive while sand and gravel deposit can be more water productive in unconsolidated formation. Aquifers may be confined or not confined; confined aquifers are overlaid by impermeable layer and prevent contamination, unconfined aquifers are directly opposite.
- z) **Occurrence of Natural Disasters:** Sudden and natural occurrences like draught, excessive rainfall, flood, hurricane, tsunami, excessive erosion and many others. When natural disasters occur, safe water accessibility is negatively affected, and available safe water is polluted; water infrastructure is damaged. Prolong draught results in water sources drying-up, and farther underground water table, dry and hazy winds as against moisture laden winds do not prognosticate same thing for safe water accessibility.

Summary, conclusion and recommendation

Factors of safe water accessibility could be summarized to be natural, anthropogenic. Natural distribution of safe water (See Fig 1), type and nature of aquifer, relief and water table, climatic factors and variability, natural disaster and the bulky nature of water. These natural factors and problems of access to drinkable water are surmountable if the expected value and desired attention is accorded to safe water provision by the relevant authorities. Similarly, the anthropogenic factors are basically human centered factors; they are problems of water accessibility created by man; they includes; economic, sociological, environmental and more importantly administrative problems. Human center problems can be more easily overcome if we will be determined and put safe water needs in its rightful place in the hierarch of needs. A concise, deliberate and intended decisions of world leaders, government administrators, policy makers and planners, community and family heads can create a new world; sustainable settlements that can guarantee safe water accessibility on the planet earth if safe water is truly valued and so treated. Determination, cohesion, agitation, collaboration and application of contemporary technology will surely reduce safe water accessibility problems in developing countries.

REFERENCES

- Abubakar, R. I. (2016). Dimensions of Public Water Services In Abuja, Nigeria. *Utilities Policy Volume 38 (C)* Elsevier, pages 43-51.
- Afrev Stech (2014): Index African Review www.aronet.infor.afreve.stech
- Alihaji, A., A. and Lawal A. (2017): Urbanization, Cities, and Health: The Challenges to Nigeria – A Review. *Annals of American Medicine*
- Awua, E. and Nyarko, K. and Owusu, P., A. (2009). Water and Sanitation in Ghana. *Journal of Desalination* Vol. 248
- (CRSTU) (2009): Cross River State Technical Unit Water Accessibility Report, *Cross River Government Press, Nigeria*
- Diagomanolin, V., Farhang, M., Ghazi-Khansari M., and Jafarzadeh, N. (2004). Heavy metals (Ni, Cr, Cu) in the Karoon waterway river, Iran. *Toxicology letters* Vol. 151 (2004) Pp 63–68
- Hanemann W. M. (Undated). *The Economy of Water*, University of California, USA 'Economic Conception of Water'
- Hanemann, W. M. (2010): *The Economic Conception of Water*. University of California. Berkeley, USA.
- Ibiang A. O., Ozah H. P., and Inah S. A. (2019). Sources and accessibility of potable water in Yakurr Local Government Area, Cross River State, Nigeria International Research Journal of Public and Environmental Health Vol.6 (5), Pp. 82-88,
- Jesse, C. R., and Nancy, L. P. (2003). A Theory of Access. *Rural Sociology* 68-(2)
- Jideonwo, T., A. (2014). Nigeria: Review of importance and challenges, status and concerns and pragmatic solutions Capstone Earth and Environmental Science University of Pennsylvania
- John, F. and Mark J. N. (2003). Contaminants in drinking water: Environmental pollution and health, *British Medical Bulletin*, Volume 68, Issue 1, December 2003, Pages 199–208,
- John, V. (2012): Water Sanitation Still Not Top Priority for African Government an environmental editor in the guardian of 30 August, (2012)
- Lawal, O. L. and Joseph, B. (2017). Access to safe water in Akure: A paradox in Nigerian Urban Regions Vol. 3. *International Journal of Emerging Knowledge*. Pp 39-45
- Nyarko, K. B., Dwumfour-Asare, B., Appiah-Effah, E. and Moriarty, P. (2010). IRC Symposium 2010 Pumps, Pipes and Promises Cost of Delivering Water Services in Rural Areas and Small Towns In Ghana
- Nwankwuala, H.O. (2010). Ground water management system, Nigeria implication for economic growth: *International journal of environment science*
- Odafiwotu, O., and Abel, A. (2014). "Access to Potable Water Supply in Nigerian Cities Evidence from Yenagoa Metropolis." *American Journal of Water Resources* 2.2 (2014): 31-36.
- Okon, I. and Njoku, C. (2017). Evaluation of Domestic Access to Pipe-Borne Water in Calabar Metropolis, Southern Nigeria. *Open Access Library Journal*, 4, 1-21.
- Omotoso, O. and Oyeniyi, S. O. (2016). Safe Water and Sanitation Situation in Ilesa Metropolis, Osun State, Nigeria. *Donnish Journal of Geography and Regional Planning* Vol. 2(2) pp. 009-014 march, 2016. <http://www.donnishjournals.org/djgrp> copyright © 2016 donnish journals
- Oyeniyi, S. O. (2019). A Comparative Analysis of Spatial Vulnerability in Slums of Southwestern States of Nigeria. (Ph.D. thesis) *UNPUBLISHED*
- Rachel, R., C., Greg, F. and Reina, F., N. (2008). *Treating the Public Water Supply: What Is In Your Water, and How Is It Made Safe*. Department of Chemistry, Washington University,
- Santra, S. C. (2013). *Environmental Science*, third edition. Central Book Agency (P) Chintamony, Das Lane Kolkata 700 09.
- United Nation's UN Water (2019). *World Water Development Report* (UNEP) (2019). United Nations Environmental Programme
- UNPD (2010). *Water Governance Facility Report*. United Nations Development Programme (UNDP), 15 July 2013. Web. 09 Apr. 2014.
- Vidal, M., Carlos, M. D., Susana, A., Josep, M. G., and Dolores V. (2003). Alkaline Phosphates' activities in the central Atlantic Ocean indicate large areas with phosphorus deficiency *Marine Ecology Progress Series Mar Ecol Prog. Ser.* Vol. 262: 43–53,
- WASH, (2012). *Water and Sanitation Summary Sheet*
- WHO, (2019). *World Health Organization New Report on Water Accessibility*
- WWF, (2016). *World Wildlife Fund; Living Planet Report*. worldwildlife.org/initiatives/fresh-water