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A COMPARATIVE ANALYSIS OF WATER SOURCES AND WATER BORNE DISEASES (TOTAL AND FAECAL COLIFORMS) IN GUSAU METROPOLIS, ZAMFARA STATE.

[1]JIBRIN AUGUSTINE CHUBIYOJO
Department of Public Health, National Open University of Nigeria
(jibrincaugustine@gmail.com)

[2]DR. TUKUR ISMAIL (MBBS, PGDE MPH, PhD)
Zamfara State University, Talata Mafara, Zamfara State.
(drsmiler2011@gmail.com)

[3]NURUDEEN SALISU
Federal University Gusau, Zamfara State.
(nsalisu@fugusau.edu.ng)

&
[4]OLAJIDE OLASUNKANMI MODUPEOLUWA
Department of Public Health, National Open University of Nigeria
(renaldsamod2003@gmail.com)

ABSTRACT
Water is an indispensable resource that is essential for human survival. It also acts as a conduit for pathogenic organism to infiltrate the human body. The study focused on assessing the bacteriological quality of water from different Sources - River, tap, wells and borehole taken within Gusau metropolis, in Zamfara state. Twenty samples, five each from each water Sources used in this study were analyzed. The total viable count was determined by pour plate technique and the total Coliform count was determined using the most probable number (MPN) technique. A total of 44 isolates were recovered and identified using the standard biochemical tests. The results of this study showed that river and tap water sources had the highest mean total viable count (TVC) 6.1 x 10^4 cfu/ml and 3.66 x 10^4 cfu/ml respectively and mean most probable number (MPN) index/100ml of 42.6 and 32.8 respectively, indicating a high level of faecal coliform contamination. Borehole and well water sources had the lowest TVC of 2.34 x 10^4 cfu/ml and 2.66 x 10^4 cfu/ml respectively and mean MPN index/100ml of 25.61 and 28 respectively, indicating a lower level of faecal contamination than river and tap sources. The most prevalent bacteria identified in this study were Klebsiella pneumoniae, while the least occurring was Pseudomonas maltophilia. In conclusion, the water sources in these studied areas pose serious public health risks as a result of the presence of coliforms found in them.

Keywords: Water sources, water borne diseases, Coliforms, Gusau.

INTRODUCTION
Water is viewed as the core of human activity since it is necessary for drinking, crop irrigation, leisure activities, and industrial use. It is crucial to safeguard this priceless natural resource from any contamination in order to prevent disease epidemics from potentially occurring. Unfortunately, problems with water quality and sanitation still occur often in underdeveloped nations (Céliada Silva Lanna et al., 2019; Montgomery & Elimelech, 2007). According to the World Health Organization (WHO) and United Nations International Children Education Funds (UNICEF) (2014), 25% of the world's population—or around 1.8 billion people—drinks water that has been contaminated by excrement. This water may contain viruses, protozoa, and bacteria that can infect people and cause a number of illnesses, most notably gastroenteritis. The effects on public health are enormous. According to estimates from Pruss-ustun et al. (2014), cholera, dysentery, and

typhoid fever account for the majority of the 829,000 annual deaths from diarrheal diseases. It should come as no surprise that diarrhea is the second most common cause of death for children under the age of five worldwide (1.2 million deaths in 2012) (Gupta, 2012).

Human life and public health depend on water. However, a sizable portion of the world's population does not have access to enough clean water to consume. More than 40% of the world's population is currently impacted by the worldwide crisis of water scarcity (Guppy & Anderson, 2017). Additionally, it is predicted that by 2025, 3 billion people would lack access to fresh water and live in water-stressed environments (Tran et al., 2016). As a result, both industrialized and developing nations continue to bear the weight of the diseases and fatalities caused by contaminated water. As a result, water-related diseases and deaths continue to be a global burden in both developed and developing countries. Poor people in rural, developing areas are disproportionately affected by the lack of access to better water, but even populations in nations with cutting-edge water and waste treatment facilities are susceptible to outbreaks of waterborne diseases. For instance, from 2009 to 2010, the United States of America recorded at least 33 outbreaks related to drinking water (Center for Disease and Control (CDC), 2013).

The environment has been degraded and polluted as a result of industrialization, agricultural production, and urban life, which has a negative impact on the rivers and oceans that are essential for life (Xu et al., 2022). This has an impact on human health and sustainable social development. Waterborne illnesses are brought on by consuming water that has been contaminated, typically by human or animal waste that contains harmful microorganisms. With 1.8 million fatalities and 4 billion episodes of illness each year, waterborne diarrhea is the most common disease in the world that causes mortality and morbidity (WHO, 2012). In addition, 90% of diarrhoeal deaths in children under-five years of age are caused by waterborne diarrhea, which is still a major source of disease and death in children in less developed nations (Nyagwencha, 2017). Water-borne illness pathogens may spread through drinking water sources in homes due to a number of circumstances. They include natural elements, including the changing climate, the availability of water, and sanitary amenities. The spread and contamination of drinking water sources are encouraged by a lack of clean water supply, inadequate excreta disposal facilities, poor hygiene, cramped living conditions, and floods following heavy rains (Pandey et al., 2014).

STATEMENT OF THE PROBLEM

Lack of safe drinking water is a threat to the public health and wellbeing of the people and exposes them to risk of water borne diseases such as diarrheal and dysentery (CDC, 2014). In Nigeria, water-related diseases are among the leading causes of death in children lower than five years of age (Food and Agriculture Organization (FAO, 2012). The most common and wide spread health risk associated with drinking water is microbial contamination. In nearly all epidemics of water borne infection, it has been observed that the microbiological quality of water was unsatisfactory (Raji & Ibrahim, 2011). Adeyinka et al. (2014) revealed that the common diseases of drinking water in Nigeria include cholera, diarrhea and typhoid fever. These and many reasons encourage this study with a view to evaluate the bacteriological quality of well water, Tap water, bore-hole water and River water in Gusau Metropolis, Zamfara state of Nigeria, in order to ascertain the water-borne diseases (Total and fecal coliforms) associated with them.

OBJECTIVES OF THE STUDY

The specific objectives of this study are:

1) To determine the total viable count of bacteria in well water, Tap water, bore-hole water and River water in Gusau, Zamfara State.
2) To identify total and fecal coliforms in well water, Tap water, bore-hole water and River water samples in Gusau, Zamfara State.
3) To enumerate total and fecal coliforms in well water, Tap water, bore-hole water and River water samples in Gusau, Zamfara State.

METHODOLOGY

An Experimental study design was employed in this study. The choice of this research design was considered appropriate because of its precision with which one can analyze the relationship between and among variables and to make the analysis as objective as possible. A convenient sampling method was use in this study. A total of twenty samples were collected for this study. These involve five (5) Samples each from boreholes, well water, Tap water and River respectively within Gusau Metropolis of Zamfara State. Water samples from boreholes, wells, Taps and river were collected from different locations within Gusau local government area of Zamfara state. A total of 20 samples of each (boreholes, wells, taps and river) were taken from these locations. Samples were collected in sterile bottles and labeled appropriately before they were transported to the microbiology laboratory of Federal University Gusau, Zamfara state, where they were analyzed.

STANDARD ANALYSIS OF WATER FOR THE PRESENCE OF COLIFORMS

The most probable Number (MPN) method was used. 10ml of samples was inoculated in 10ml of double strength MacConkey broth medium; while 1ml and 0.1ml of samples was also inoculated in the single strength test tubes. They were then incubated aerobically at 37^{o}C for 48hours.

Presumptive Test

The inoculated medium was observed at both 24 and 48hours for the presence of gas. This was observed by the appearance of air bubbles in the durham tubes. The appearance of gas in the first 24hours signified a positive presumptive test whereas the appearance of gas in the next 24 hours signifies a doubtful test.

The confirmatory test was performed for all samples giving positive or doubtful results. The smallest inoculums from the tubes testing positive or doubtful for presumptive test was streaked on the EMB agar plate using an inoculating wire loop before incubating at 37^{o}C for 48hours; after which colonies showing typical characters of coliform were observed (APHA, 2017).

Complete Test

Each colony from the EMB agar plates were picked with the aid of an inoculating wire loop and transferred into slant bottles containing molten agar medium before they were incubated at 37^{o}C for 48hours.

ENUMERATION OF TOTAL VIABLE COUNT

This was done using nutrient agar by pour plate technique. A small volume (1ml) of each appropriate dilute (sample) was distributed to separate sterile Petri dishes containing approximately15ml of molten agar medium. The content of the petri dishes was then swirled to ensure even distribution of the sample throughout the medium.

The plated were then allowed to cool and solidify on a septic surface. They were then placed in an incubator at a temperature of 37^{o}C for 48hours.

After 48hours of incubation, the petri dishes were taken out and the colonies that have developed on the agar surface were counted using colony counter, according to the APHA, (2017).

The total viable count can be expressed as: $\frac{\text{Number of colonies x dilution factor}}{\text{Volume of samples in plate}}$

Biochemical characterization of the isolates

The biochemical tests were carried out according to standard protocols. Gram staining tests, Indole, Methyl Red, Voges-Proskauer test, urease, catalase and Citrate tests were done for the classification of enteric bacteria.

RESULTS

The first objective of this research study was to check the total viable bacteria count as well as to check the total coliform count. The measure used to ascertain the total viable bacteria count was in colony forming unit per mililiter (CFU/ml) while the measure used to ascertain the total coliform count was the most probable number. The water sources used were 5 each of well, River, Tap and borehole. The details of the individual MPN and CFU/ml of the sources are shown below.

Table 1: Table showing total viable count and total coliform count in individual water sources

Water Sources	10ml	1.0ml	0.1ml	MPN index/100ml	CFU/ML
RIVER A	5	1	2	60	7.3×10^4
RIVER B	5	2	1	70	9×10^4
RIVER C	5	1	0	30	6.1×10^4
RIVER D	4	1	2	26	4.2×10^4
RIVER E	4	3	0	27	5.3×10^4
TAP Samaru	4	3	0	27	2.5×10^4
TAP T/wada	4	4	0	34	4.0×10^4
TAP W/Board	4	1	2	26	2.4×10^4
TAP P/Road	4	3	0	27	3.3×10^4
TAP S/gari	5	2	0	50	6.1×10^4
B/H Samaru	4	1	2	26	2.1×10^4
BH T/wada	4	2	1	26	1.9×10^4
BH G/biyu	4	2	1	26	2.8×10^4
BH A/Dallatu	4	0	1	17	1.1×10^4
BH S/gari	4	3	1	33	3.8×10^4
WELL Samaru	4	1	1	21	3.2×10^4
WELL T/wada	4	4	0	34	3.0×10^4
WELL P/Road	4	1	2	26	2.6×10^4
WELL A/Dallatu	4	2	1	26	1.7×10^4
WELL S/gari	4	3	1	33	2.8×10^4

The table above shows the individual total coliform number by the water sources. The analysis shows that with respect to total viable count, river sources and tap sources had the highest total viable count with the highest total viable count of 9×10^4 cfu/ml and 6.1×10^4cfu/ml respectively. The highest total viable count for well water and river water sources was 3.2×10^4 cfu/ml and 3.8×10^4 cfu/ml respectively.

Furthermore, with respect to total coliform count, river and tap sources had the highest MPN index/100ml of 70 and 50 respectively. The highest MPN index/100ml of well and borehole water was 34 and 33 respectively. To further buttress on the table above the average total viable count and average total coliform count along with the range was analyzed across each water source as seen in the tables below:

Table 2: Table showing Mean total viable count in water sources

Water Sources	AVERAGE of CFU/ML	SD	Range
BH	2.34	0.72	1.1-3.8
RIVER	6.38	1.57	4.2- 9.0
TAP	3.66	1.29	2.4 -6.1
WELL	2.66	0.48	1.7-3.2
Grand Total	**3.76**	**0.92**	**1.1-9**

The table above shows the mean total viable bacteria count by sources. The table shows that the river sources have the highest mean total viable count of 6.38 x 10^4 cfu/ml with the tap water sources having the next highest mean of 3.66 x 10^4 cfu/ml. The borehole and well water sources had the lowest mean with the total viable count of 2.34 x 10^4 cfu/ml and 2.66 x 10^4 cfu/ml respectively.

The table below shows the mean MPN index/100ml by sources. The table shows that the river sources have the highest mean MPN index/100mlof 42.6 with the tap water sources having the next highest mean of 32.8. The borehole and well water sources had the lowest mean with the total viable count of 25.6l and 28 respectively.

Table 3: Table showing Mean total Coliform count in water sources

Water_Sources	AVERAGE of MPN index/100ml	SD	Range
Borehole	25.6	5.39	17-33
RIVER	42.6	9.52	26-70
TAP	32.8	10.17	26-50
WELL	28	7.36	21-34
Grand Total	**32.25**	**10.46**	**17-70**

To check if the difference between the total viable count and total coliform count was statistically significant, A Kruskall Wallis test was conducted which compares the mean of both values and tells from significance level displayed if the difference of the mean is significant. The table below shows the test conducted.

Table 4: Kruskal Wallis table showing statistical significance in difference in mean total viable count and mean total coliform count in water sources

	Mean Rank						
	Borehole	River	Tap	Well	Kruska-Wallis	Df	Sig
Total Viable count	5.90	17.50	10.90	7.70	11.183	3	0.011
MPN/100ml	6.70	13.80	12.50	9.00	4.732	3	0.019

The table shows that for both MPN and total viable count, the difference in total viable count and total coliform count across the water sources is statistically significant.

The second objective of this research was to identify the total and fecal coliforms in water sources. There were 4 sources of water used in this research (River, Well, Borehole and tap). 5 different sources of this primary source of water were used for this research which amounted to 20 samples. Organisms were

identified in all the samples. The isolates amounted to 48 which comprised of 10 organisms been identified in the 20 samples. Details of the biochemical test can be seen in Appendix I. A pie chart was drawn up to show the individual organism and how many times they appeared in the samples. Details of this are shown below:

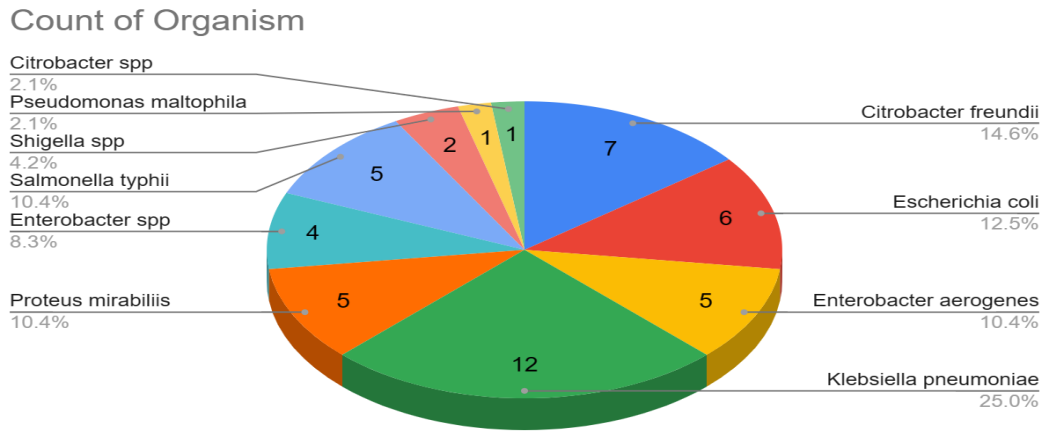

Figure 2: Pie chart showing distribution of organism

The pie chart test showed that the most prevalent organism was Klebsiella pneumonia which appeared 12 times followed by *Citrobacter freundii* which appeared 7 times. *Enterobacter aerogenes* and *Salmonella Typhi* appeared 5 times each. The least occurring organism was *Citrobacter spp* and *Psudomonas maltophilia* which appeared just once.

Table 5: Cross tabulation table showing individual number of organisms in water sources

		Water sources				
		Bore hole	River	Tap	Well	Total
Organisms	*Citrobacter freundii*	3	1	2	1	7
	Citrobacter spp	0	0	0	1	1
	Enterobacter aerogenes	1	2	2	0	5
	Enterobacter spp	0	1	1	2	4
	Escherichia coli	0	5	0	1	6
	Klebsiella pneumoniae	4	3	3	2	12
	Proteus Mirabiliis	1	1	1	2	5
	Pseudomonas maltophila	0	0	1	0	1
	Salmonella typhi	1	1	3	0	5
	Shigella spp	0	1	1	0	2
Total		10	15	14	9	48

The table above as well as the bar chart below shows that *Citrobacter freundii*, *Klebsiella pneumonia* and *Proteus mirabiliis* appeared in all the sources of water. Furthermore the table showed that the highest occurring organism was *Klebsiella pneumonia* forborehole water with the count of 4 isolates, *Escherichia coli* for river water sources with the count of 5 isolates, *Klebsiella pneumonia* and *Salmonella typhi* for tap sources with the count of 3 isolates each and *Enterobacter spp*, *Klebsiella pneumonia* and *Proteus Mirabiliis* for well water sources with a count of 2 isolates each. The lowest occurring organisms *Pseudomonas maltophila* and *Citrobacter spp* with an occurrence of 1 appeared in tap and well water respectively.

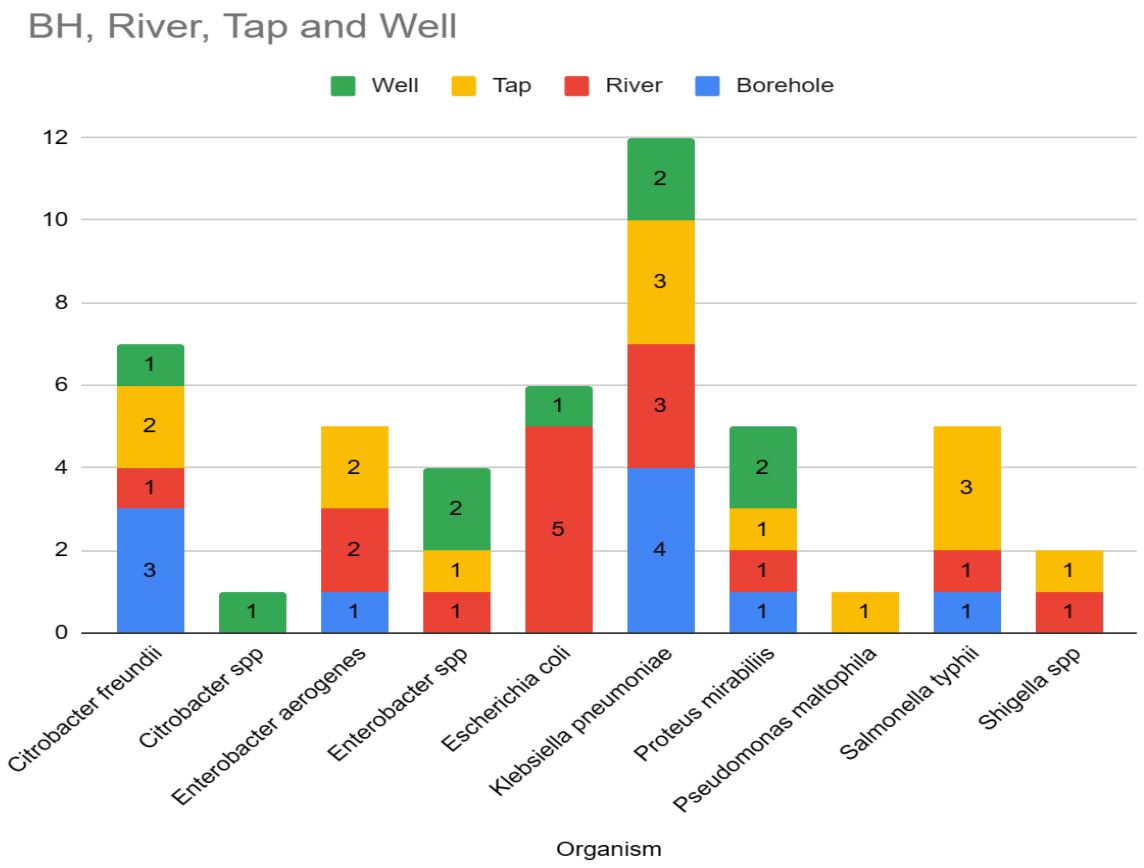

Figure 4: Compound bar chart showing individual number of organisms in water sources

To check if the distribution of the organism across the water sources was statistically significant, a chi square test was conducted as seen in the table below:

Table 8: Chi square table showing significance in distribution of individual number of organisms in water sources

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	28.374[a]	27	.392
Likelihood Ratio	30.558	27	.290
Linear-by-Linear Association	.088	1	.767
N of Valid Cases	48		

The chi square test showed that the distribution of the organisms across the water sources was not statistically significant.

Conclusion

In conclusion, this study revealed that the microbial quality of water from different sources varied significantly, with river and tap water being the most contaminated and borehole and well water being the least contaminated. However, none of the sources were free from potentially pathogenic bacteria, such as *Salmonella typhi*, *Escherichia coli*, and *Klebsiella pneumoniae*. Therefore, there is a need for regular monitoring and treatment of water sources to ensure safe drinking water and prevent waterborne diseases.

Recommendation

Based on the findings of this research, the following recommendations were made:

1. Water sources should be treated before consumption or use for domestic purposes with more emphasis on tap and river water sources. This is because both water sources are the most contaminated with coliform bacteria that can cause various diseases and infections in humans and animals. Therefore, there is a need for effective water management and policy making in Gusau to ensure the provision of safe and adequate water supply for the population. The treatment methods should include boiling, chlorination, filtration or disinfection with ultraviolet light or ozone.
2. It is also recommended that regular monitoring and testing of well water and borehole water should be carried out to ensure their microbiological quality and safety.
3. Furthermore, it is suggested that more research should be done on the factors that influence the occurrence and distribution of coliform bacteria in water sources, such as environmental conditions, human activities, animal waste and soil characteristics.

References

Adeyinka, S.Y., John, W., & Akintayo, C.O. (2014). Review of Waterborne Diseases in Nigeria. Journal of Advancement in Medical and Life Sciences, 1(2), ISSN: 2348-294X. Retrieved from http://www.scienceq.org.journals.JALS.php

American Public Health Association (APHA). (2017). Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington, DC: Author.

Célia da Silva Lanna, M., Viancelli, A., Michelon, W., Castro Carvalho, S. V., de Almeida Dos Reis, D., Fernandez de Salles, L. A., Sant'Anna, I. H., Resende, L. T., de Souza Ferreira, C., Aparecido das Chagas, I., Hernández, M., Treichel, H., Rodríguez-Lázaro, D., & Fongaro, G. (2019). Household-based biodigesters promote reduction of enteric virus and bacteria in vulnerable and poverty rural area. Environmental pollution (Barking, Essex : 1987), 252(Pt A), 8–13. https://doi.org/10.1016/j.envpol.2019.05.104

Center for Disease control and Prevention, (2013). Morbidity and Mortality Weekly Report: Recommendations and Reports, 62(5). http://www.jstor.org/stable/24832558

Centres for Disease Control and Prevention [CDC]. (2014). GLOBAL WASH-Related Diseases and Contaminants. Retrieved July 21, 2014, retrieved from http://www.cdc.gov/healthywater/wash_disease.htm

Food and Drug Administration [FDA]. (2012). U.S. Department of Health and Human Services. Bad Bug Book-foodborne Pathogenic Microorganisms and Natural toxins Handbook, 2nd Ed. Retrieved from http://www.fda.gov

Guppy, L. and Anderson, K. (2017) Global Water Crisis: The Facts.

Gupta G. R. (2012). Tackling pneumonia and diarrhoea: the deadliest diseases for the world's poorest children. Lancet (London, England), 379(9832), 2123–2124. https://doi.org/10.1016/S0140-6736(12)60907-6.

Montgomery, M. A., & Elimelech, M. (2007). Water and sanitation in developing countries: including health in the equation. Environmental science & technology, 41(1), 17–24. https://doi.org/10.1021/es072435t.

Nyagwencha, J.M., Kaluli, J.W., Home, P.G, and Murage, H. (2017) Access to Safe Drinking Water and Water-Borne Diseases in Masaba North District, Kenya. JKUAT Annual Scientific Conference, 688-694.

Prüss-Ustün A, Bartram J, Clasen T, Colford JM Jr, Cumming O, Curtis V, et al.(2014), Burden of disease from inadequate water, sanitation and hygiene in low-and middle-income settings: a retrospective analysis of data from 145 countries. Trop Med Int Heal.;19:894–905.

Raji, M.I.O., & Ibrahim, Y.K.E. (2011). Prevalence of Waterborne Infections in Northwest Nigeria: A Retrospective Study. Journal of Public Health and Epidemiology, 3(8), 382-385. Retrieved from http://www.academicjournals.org/phe

Tran, M., Koncagul, E. and Connor, R. (2016) Water and Jobs: Facts and Figures. United Nations World Water Development Report, United Nations, New York, 1- 12.

World Health Organization. (2012). Burden of Diseases and Cost-Effectiveness Estimates. Available from: https://www.en.wikipedia.org/wiki/waterborne-diseases.

WHO, UNICEF (2014) Progress on drinking water and sanitation: 2014 Update Geneva, Switzerland: WHO Press.

Xu, X., Yang, H., & Li, C. (2022). Theoretical Model and Actual Characteristics of Air Pollution Affecting Health Cost: A Review. International journal of environmental research and public health, 19(6), 3532. https://doi.org/10.3390/ijerph19063532