Original Research Article

FLOOD ASSOCIATED BACTERIOLOGICAL STATUS OF A WATER BODY IN A RURAL NIGER DELTA COMMUNITY, DELTA STATE, NIGERIA.

ABSTRACT

Floods are high volumes of water over areas that are normally dry land, and are among the most frequent and costly natural disasters. The aim of this work was to evaluate the impact of flooding on the bacteriological quality of a water body in a rural Niger Delta Community in Delta State, Nigeria. Water samples were collected from three different points such as the Right Bank, Left Bank and Mid-Point of the river at a monthly interval, from October (the peak of the flood) to December 2019, when the flood has finally receded. The samples were analyzed for the diverse bacterial groups using standard bacteriological methods. The highest total heterotrophic bacterial counts of 5.6±0.1 x 10^6 cfu/ml and the highest total coliform counts of 1.6±0.3 x 10^4 cfu/ml were recorded in the month of October, while the least total heterotrophic bacterial counts of 1.2±0.1 x 10^5 cfu/ml and the total coliform counts of 1.0±0.2 x 10^3 cfu/ml were recorded in the month of December. Six (6) bacterial species, belonging to four (4) genera were purified and identified as *Bacillus*, *Staphylococcus, Klebsiella and Escherichia coli*. *Bacillus* spp. (*B. cereus; B. lentus*; *B. subtilis*) were the most predominant bacterial species, with a percentage occurrence of 37.5 %. *Staphylococcus and Klebsiella* spp were at par in their occurrence of 25 % each, while *Escherichia coli* was on the other hand the least occurring bacterial species (12.5%). The results hence, showed that the bacterial population differed with regards to the sample period, as the highest counts were obtained in the month of October when the flood was at its peak and decreased as the flood receded. Therefore, flooding increases the risk of bacterial mediated waterborne infections in impacted localities. It is therefore recommended that those living within vicinities affected by the flood should vacate the environment to avoid unnecessary associated risk.

Keywords: Bacteriological status, flood, Niger Delta Community, Water body.

1. INTRODUCTION

Several definitions have been used to characterize flooding. However, in a very simple term, flooding can be said to be a condition whereby water overflows over a usually dry land. According to Meghan, 2017 [1], floods are high volumes of water flow over areas that are normally dry land.

The term water quality is attributed to the physical, chemical, and biological properties of water, in relation to its suitability for use [2]. Several factors including anthropogenic and natural factors influence the quality of water. Flooding is one of the factors that can greatly impact on water quality.

Reports from previous studies have indicated that floods vary from those that develop slowly during following a prolonged period of rain, or in a warning trend following a heavy snow, to also include flash floods that can occur quickly, even without any visible signs of rain [3].

Flooding have been known to present environmental and health challenges in flood prone areas. They are associated with disease outbreaks, mostly in the low-income countries of Asia and Africa [4]. They increase the spread of water-borne diseases such as typhoid fever, cholera, leptospirosis and hepatitis A, as well as vector-borne diseases, namely malaria, dengue hemorrhagic fever, yellow fever and West Nile fever [4]. Waterborne pathogen contamination and related diseases are major concerns throughout the world [5].

In some developing countries such as Nigeria, surface and ground water has remain their major sources of domestic [6], making most rural dwellers and their visitors being at risk of gastrointestinal problems associated with contaminated water. The impact of flooding on water quality in such regions will have a large bearing on human health as well as on the aquifer environment. The ingestion of bacteria such as *Salmonella typhi* and *Salmonella paratyphi* triggers the severity. These human restricted pathogens with no animal reservoir get transmitted through contaminated food, water or contact with fecal matter from infected individuals [7]. When flood occur, even the usually safe groundwater may become unsafe, this is because a vast majority of run off, and wash off occurs simultaneously, it gives room to various habitats to have contact with each other. For example, a contaminated river during flooding must have been as a result of habitats such as sewage been washed off with flood water, which in turn inundates the wells and other water bodies that would have resulted in contaminating the groundwater. Genetic similarity have been reported between bacteria from various locations during flooding, implying that they must have originated from a single domestic sewage source containing fecal matter [8].

The Western Niger Delta area is traversed by numerous flat-floored rivers that drain into the Atlantic Ocean. Some important rivers in this area are the Ethiope, Warri and the Kiagbodo rivers. These rivers are prone to flooding, especially during the wet season, mainly because of the heavy rainfall, high ground water table and the flat-floored valleys. Large stretches of most rivers, especially the lower reaches of the Ethiope, Warri and the Kiagdodo rivers are permanently waterlogged [9]. Rivers are important in that they carry water and nutrients to areas all around the earth. They play a very important part in the water cycle, acting as drainage channels for surface water. Rivers drain nearly 75% of the earth's land surface. They provide excellent habitat and food for many of the earth's organisms, as well as serving as travel routes for exploration, commerce and recreation. They are also important energy source, and serve as means of irrigation for farmers [10]. River banks offer multiple uses in several sectors of development like agriculture, industry, transportation, aquaculture, and public water supplies [11]. Rivers have also been used for cleaning and disposal of waste and may become polluted by indiscriminate disposal of sewage, industrial waste, agricultural practices and human activities, which all affect their microbiological quality [12]. Therefore, giving considerations to the importance of rivers, it is necessary to keep its water contents at optimum condition. The occurrence of flood poses a major threat to the quality of river water, in that, it allows other unsafe habitats such as sewage to come in contact with river water, thereby deteriorating the quality of river water. Some of these rivers are used for domestic purposes such as washing of food products (cassava) or utensils. Such activity increases the possibility of transmitting diseases. A water body with high bacteriological load can bring about the outbreak of epidemics. Thus, with respect to the ongoing flood in the Niger Delta region, it is important to assess the bacteriological quality of associated rivers.

There is limited information available in the published literature, describing the type and quantity of contaminants and pathogens found in flood waters. A few studies found increased rates of diarrhea or other illness after heavy rainfall or flooding [13], which suggests that increased microbial loads may be present in water bodies during and after flooding; however, these studies did not investigate which individual pathogens were in the water. In addition to the immediate risk of drowning, floods can flush toxic chemicals and infectious microorganisms from soil as well as residential, industrial, agricultural, and waste facilities into storm drains, rivers, and residential areas [13]; [14]; [15]. This places residents and emergency responders at risk of exposure to contaminated water. The increase in the spread of water-borne diseases such as typhoid fever, cholera, leptospirosis and hepatitis A, as well as vector-borne diseases namely malaria, dengue hemorrhagic fever, yellow fever and West Nile fever are all associated with contaminated water. Some other infectious diseases have high mortality rate which can be detrimental to the human population. Flooding has the potential to make groundwater unsafe for human use [8]. Rivers such as the Kiagbodo River that are close to human dwelling are at high risk of contamination due to various anthropogenic activities involving the water body as well as the impact of flood. This therefore prompts the need for the bacteriological quality assessment of the river, to evaluate the impact of flooding on the diversity and population dynamics of bacterial species in the River.

2.0 MATERIALS AND METHOD

2.1 Description of Study Area and Duration

The study was carried out at Kiagbodo River, in Burultu Local Government Area of Delta State, for period of three (3) months: October to December 2019.

2.2 Sample Collection

Surface water samples were collected from three (3) different points such as Right bank, Left bank and Midpoint of the River (Table 1) at a monthly interval, from October (the peak of the flood) to December (when the flood has finally receded). Sterile bottles used in collecting the water from the river were covered tightly to prevent further contamination and refrigerated at 4^0C prior to use.

2.3 Estimating the Bacterial Population in the Water Samples

The population of heterotrophic and coliform bacteria were enumerated using the spread plate technique. A serial 10-fold dilution of the water samples was carried out by transferring 1 ml of the sample into a sterile test tube containing 9 ml of sterile physiological saline. From here, a serial ten-fold dilution was performed up to dilutions of 10^{-5}. From each dilutions, 0.1 ml was inoculated on respective agar plates (Petri dishes). However, a triplicate plating of each dilution was employed. A sterile glass rod (spreader) was used to spread the inoculums over the media. The plates were incubated in an incubator at 37$^{\mathbf{0}}$**C** for 24 hours. MacConkey agar plates that showed no growth or insufficient growth were allowed to stay for 48hrs for clarity.

2.4 Isolation of Pure Culture

To get a pure culture, an inoculum of the colonies was taken and sub cultured on fresh agar plates using the streak plate method. This was done using a sterile wire loop, the inoculum was then deposited on a plate containing a fresh media and streaked up and down the surface of the media, which was later incubated for 24-48 hours.

3.0 RESULT

3.1 Impact of Flooding on the Bacterial Population Dynamics in the River Water

The enumeration of the bacterial population was carried out at the peak of flooding, during the receding period, and at the post flood period, to assess the impact of flooding on the bacteriological quality of the river water. The result revealed that the population varied with regards to the sample period, as the highest counts were obtained in the month of October, 2019 when the flood was at its peak. From the result shown in the Table 1, it was also observed that the counts decreased as the flood receded, with December, 2019 (the post flood period) showing the least count.

The highest total heterotrophic bacterial count of 5.6±0.1 x 10^6 cfu/ml was recorded in the month of October 2019, while the least total heterotrophic bacterial count of 1.2±0.1 x 10^5 cfu/ml was recorded in December 2019 from the post flood sample. Same trend was also observed for the total coliform bacterial count (Figure 1).

3.2 Changes in Bacterial Load at Different Points in the River – Left Bank, Right Bank and Middle Point.

Water samples were collected from the left bank, right bank and middle point across the river. The result presented in Table 1 showed the bacterial counts varied, with the left bank samples showing higher bacterial counts than the right bank throughout the study period. It was also recorded that except for the month of December, 2019, where the middle point showed the highest total heterotrophic bacterial count of 3.6±0.2 x 10^5 cfu/ml, the left bank maintained the highest count amongst the three sample locations (Left bank, Right bank and Midpoint of the river).

Table 1: TOTAL HETEROTROPHIC BACTERIAL AND TOTAL COLIFORM COUNT (cfu/ml).

SAMPLE ID	THBC	LOG_{10} THBC	TCC	LOG_{10} TCC
OCTOBER 2019				
Left bank	5.6±0.1 x 10^6	6.75	1.6±0.3 x 10^4	4.20
Mid-point	4.7±0.1 x 10^6	6.67	2.5±0.2 x 10^4	4.40
Right bank	3.5±0.2 x 10^6	6.54	-	-
Mean LOG_{10}		**6.65**		**4.30**
NOVEMBER 2019				
Left bank	5.1±0.2 x 10^6	6.71	3.2±0.1 x 10^4	4.51

Mid-point	3.0±0.1 x 10^5	5.48	-	-
Right bank	6.0±0.3 x 10^5	5.78	2.0±0.1 x 10^3	3.30
Mean LOG_{10}		**5.99**		**3.91**
DECEMBER 2019				
Left bank	1.4±0.1 x 10^5	5.15	1.0±0.2 x 10^3	3.0
Mid-point	3.6±0.2 x 10^5	5.56	5.2±0.1 x 10^4	4.71
Right bank	1.2±0.1 x 10^5	5.08	-	-
Mean LOG_{10} THBC		**5.26**		**3.86**

Key:

NG = No Growth

THBC = Total Heterotrophic Bacterial Count

TCC = Total Coliform Count

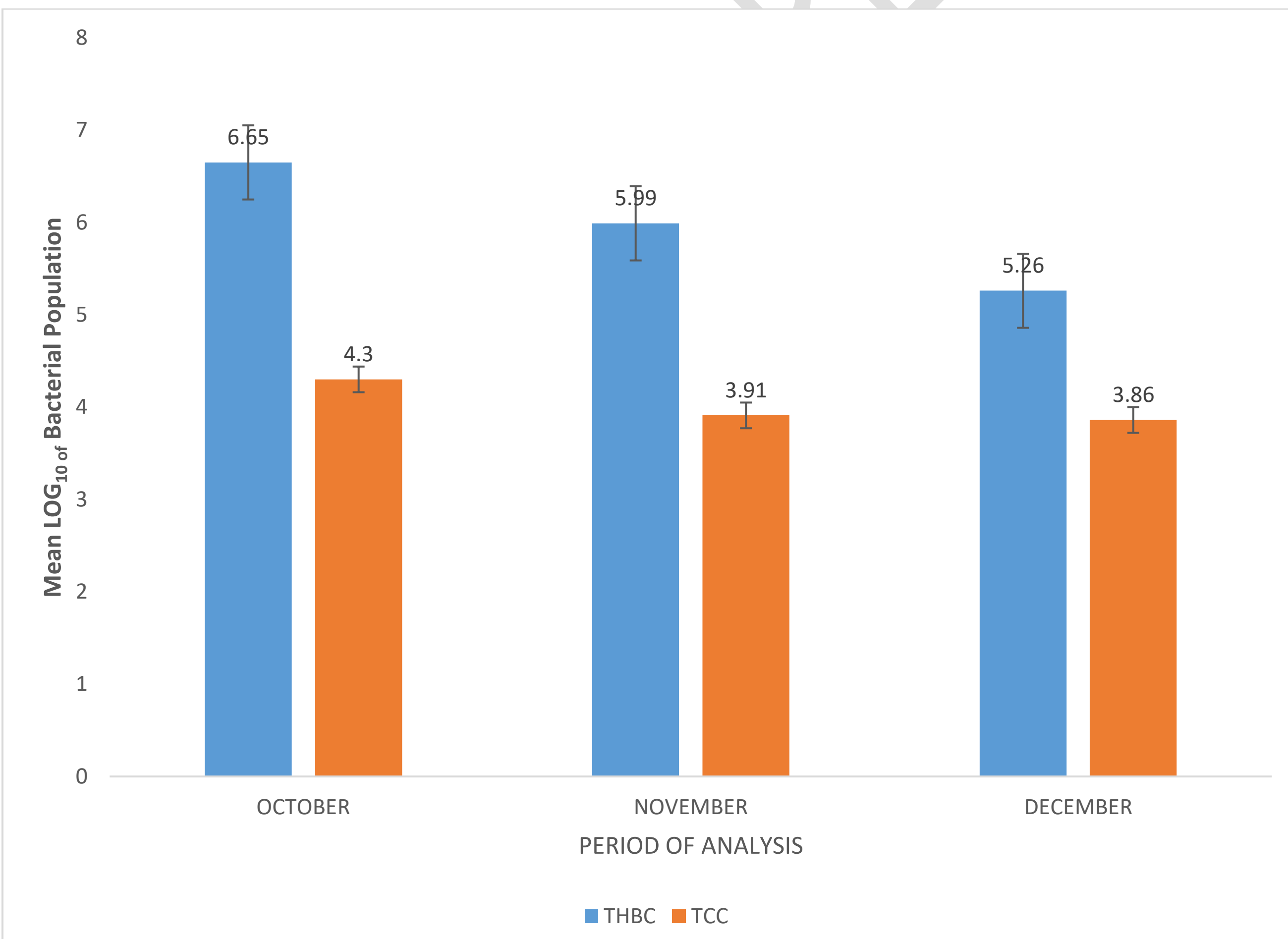

Figure 1: Changes in bacterial counts with respect time (October, 2019 - December, 2019).

3.3 Bacterial species in the River Water Samples

Six (6) bacterial species, belonging to four (4) genera were purified and identified as *Bacillus, Staphylococcus, Klebsiella and Escherichia*. The percentage occurrence of the diverse bacterial genera is as shown in Table 2. The result reveals that *Bacillus* (*B. cereus; B. lentus*; *B. subtilis*) was the most predominant bacterial genera, with a percentage occurrence of 37.5 %. *Staphylococcus and Klebsiella species* were at par in their occurrences (25 % each), while *Escherichia coli* was on the other hand the least occurring bacterial species (12.5%).

Table 2: Percentage occurrence of the isolates.

ISOLATES	FREQUENCY	PERCENTAGE (%)
***Bacillus* spp.**	9	37.5
***Staphylococcus* sp.**	6	25.0
Escherichia coli	3	12.5
***Klebsiella* sp.**	6	25.0
TOTAL	**24**	**100**

4.0 DISCUSSION

Flooding are the most common naturally occurring hazard responsible for a greater number of fatalities globally [16] and has in recent time become one of the frequently most occurring natural disasters in Nigeria, most especially in the Niger Delta region. Due to the problem of shelter, most rural dwellers are left with the sole option of living within the flooded areas. River water bodies are one of the ecosystems affected by flooding and a large proportion of human population within the Niger Delta region hardly do without dependence on River water. This therefore necessitated the need to pry into the influence of flooding on the bacteriological profile of a river water, in a rural setting, in order to decipher the public health implications of flooding.

The results of the analysis on the impact of flooding on the bacterial population dynamics in the river water revealed that the population varied with regards to the sample period, as the highest counts were obtained in the month of October, 2019 when the flood was at its peak and reduced as the level of flood receded. This decline in the total heterotrophic and coliform bacterial population was observed in the months of November, 2019 and December, 2019, with December showing the least count. This therefore implies that flooding resulted in an increase in the bacterial population in the study area.

This observed difference could be as a result of contamination from various sources like sewage coming in contact with the river water and thereby reducing the quality of river water. Other possible sources of contamination could be from farm lands, abattoirs, poultry farms, piggeries and other anthropogenic sources [13]; [14]; [15].

Previous studies on the impact of flooding on the microbiological properties of river water have also indicated a higher microbial load in flood water than post flood river water. A study by [17] to assess the effects of the 2005 flooding in Jakarta, Indonesia found that flood water contained higher levels of total coliforms, *E. coli*, enterovirus, hepatitis A virus, norovirus G1 and G2 compared to normal river water.

The changes in bacterial load at different points in the river, with respect to Left bank, Right bank and Middle point was noted in this study. It was observed from the results presented in Table 1 that the bacterial counts varied, with the left bank samples showing higher bacterial counts than the right bank throughout the study period. Also. It was noted that except for the month of December, 2019, where the midpoint showed the highest total heterotrophic bacterial count of 3.6±0.2 x 10^{5}, the left bank still maintained the highest count among the three samples throughout the study period. The reason behind the left bank having higher bacterial load could be as a result of human activities around the river bank, where the right bank is directly opposite the human settlement (residential area), with less human activities. The observation in this work corroborates with the findings of [18]. They noted higher bacterial densities in the upper, middle and lower stretches at Thenkasi, Tirunelveli and Punnakayal, respectively, and attributed it to dense populations, mass visiting, and holy dipping. It can be stated from this study that the bacterial population around river banks may vary depending on the season and level of water as well as proximity to human settlement.

A study on the bacterial species abundance in the river water during the study period recorded six (6) bacterial species, belonging to four (4) genera, purified and identified as *Bacillus, Staphylococcus, Klebsiella and Escherichia*. The study further showed the percentage occurrence of the diverse bacterial genera, with *Bacillus* spp. (*B. cereus; B. lentus*; *B. subtilis*) being the most predominate. *Staphylococcus and Klebsiella species* were at par in their occurrence, while *Escherichia coli* was on the other hand the least occurring bacterial species (12.5%). The higher prevalence of *Bacillus species* in this study could be as a result of higher contamination from edaphic sources. The presence of *E. coli*, albeit the least occurring, is indicative of recent contamination of human origin, and therefore of a great public health concern.

The bacterial population seen in this study have been reported in previous studies, to be associated with to water quality [19]; [20]; [21] and as potential human pathogens capable of causing different disease in humans, including swimmers ear as well as skin infections and have been linked with some major outbreaks [22].

5.0 CONCLUSION

Flood is one of the major natural factor that influences water bodies, and affect human health as well as the environment. From the research carried out, it has been observed that flooding increases the bacteriological quality of river water, as the population of both the coliform and heterotrophic bacteria were higher during the flood period compared to the post flood period and therefore presents a higher health risk.

The study further observes that left bank of the river (which is closer to human settlement) had higher bacterial load compared to the right bank, and therefore concludes that bacterial population around river banks may vary depending on the season and level of water, as well as proximity to human settlement.

From available literatures, this research is apparently the first research to be carried out on the impact of flooding on the bacteriological quality of Kiagbodo River and therefore contributes to scientific knowledge , as it will serve as a useful tool for future research work in the this area.

Although this study represents only a single flood event and the sample size was limited, the findings reinforce the need to practice commonly recommended guidelines for exposure to flood water.

REFERENCES

1. Meghan S, (2017). Floodwater and storm water can contaminate your water well. Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. https://water.unl.edu/article/drinking-water-wells/floodwater-and-stormwater-can-contaminate-your-water-well (Accessed on the 14th November, 2019).

2. UNEP/WHO, (1996). Water Quality Monitoring- A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. United Nations Environment Programme and the World Health Organization.

3. Pilgrim, D. H., Chapman, T. G. and Doran, D. G. (1988). Problems of rainfall-runoff modelling in arid and semi-arid regions. *Hydrol. Sci. J.* 33(4): 379–400.

4. Torti J. (2012). Floods in Southeast Asia: A health priority. *J. Global Health*. 2,1–6.

5. Pandey P. K., Kass P. H., Soupir M. L., Biswas S. and Singh V. P, (2014). Contamination of water resources by pathogenic bacteria. *AMB Express*. 4:1–16.

6. Kulinkina A. V. (2016). *Seasonality of water quality and diarrheal disease counts in urban and rural settings in south India.* Sci. Rep. 6: 1–12.

7. Lebaron, P., Cournoyer, B., Lemarchand, K., Nazaret, S. and Servais, P. (2015). Environmental Microbiology: Fundamentals and Applications. Ed: Bertrand *J. Springer*. *4: 15*.

8. Bhavya K, (2017). Floods in polluted rivers can pollute groundwater too. https://www.downtoearth.org.in/news/science-&-technology/amp/floods-in-polluted rivers-can-pollute-groundwater-too-59007 (Accessed on 15th November, 2019).

9. Albert, A. (2002). Outline Geography of Urhobo Land. University of Ibadan, Nigeria. www.waado.org/geography/UrhoboGeography-Aweto.HTM (Accessed on the 16th November, 2021).

10. Mandy, B. (2019) Why are rivers important? www.primaryhomeworkhelp.co.uk/rivers/importance.HTML (Accessed 15th November, 2021). .

11. Kumarasamy, P., Dahms, H.U., Jeon, H.J., Rajendran, A. and James R. A. (2013). Irrigation water quality assessment - an example from the Tamiraparani River. *South India Arab J Geosci* 10: 1146-4

12. McLellan, S. L., Salmore, A. K. (2003) Evidence for localized bacterial loading as the cause of chronic beach closings in a freshwater marina. *Water Res* 37: 2700–270

13. Hunter, P. R. (2003). Climate change and waterborne and vector-borne disease. *J. Appl. Microbiol.* 94: 37–46.

14. Kistemann, T. Classen, T. Koch, C., Dangendorf, F. Fischeder, R, Gebel, J. Vacata, V. and Exner, M. (2002). Microbial load of drinking water reservoir tributaries during extreme rainfall and runoff. *Appl. Environ. Microbiol*. 68(5): 2188–2197.

15. Rose, J. B., Epstein, P. R., Lipp, E. K, Sherman, B. H., Bernard, S. M. and Patz, J. A. (2001). Climate variability and change in the United States: potential impacts on water- and foodborne diseases caused by microbiologic agents. *Environ. Health Perspect*. 109(2): 211–221.

16. Doocy, S., Daniels, A., Murray, S. and Kirsch, T. (2013). 'The human impacts of floods: A historical review of events 1980–2009 and systematic literature review', *PLoS Currents Disasters;* 1-29.

17. Phanuwan, C., Takizawa, S., Oguma, K., Katayama, H., Yunika, A. and Ohgaki, S. (2006) Monitoring of human enteric viruses and coliform bacteria in waters after urban flood in Jakarta, Indonesia. *Water. Sci. Technol.* 54(3): 203–210.

18. Vignesh, S., Dahms, P., Rajendran, A., Kim, B.and James, R. A. (2015). Microbial Effects on Geochemical Parameters in a Tropical River Basin. *Environ. Process*. 2: 125–144

19. Sampson T., L. K. Giami and J. A. Okedike (2021). Phenotypic Characterization of Bacteria Isolated from the Recreational Sites of Two Rivers in Orashi Region, Rivers State, Nigeria. *South Asian Journal of Research in Microbiology*. 9(3), 16-23.

20. Akani, N. P., Sampson, T., G. C. Disegha and V. Vincent-Okwuosa (2021). Physicochemical and Bacteriological Quality of Water from Storage Tanks in a Tertiary Institution in Rivers State, Nigeria. *Journal of Advances in Microbiology*; 21(6), 6-17

21. Sampson, T. and K.B.D. Yom (2021) Sequence-based Bacteriological Probing of Domestic Water Sources in Kiagbodo, Delta State, Nigeria. *Acta Scientific Microbiology*. 4 (6), 18 – 24.

22. Hlavsa MC, Cikesh BL, Roberts VA. Outbreaks Associated with Treated Recreational Water-United States, 2000-2014. MMWR Morb Mortal Wkly Rep. 2018; 67:547-551.