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Water quality, typhoid endemicity and public health issues within Buea Urban Space, South-West Region of Cameroon

Qualité de l'eau, endémicité typhoïdique et santé publique dans l'espace urbain de Buea, Région du Sud -Ouest, Cameroun

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Abstract:

Typhoid a water borne disease cause by Salmonella typhi, remains a major public health concern in Africa and Asia. The aim of this study was to examine the correlation between water quality and typhoid endemicity within Buea urban space. The methodology used was based on the ECOHEALTH approach and bacteriological analysis of water samples. Questionnaires were administered to 200 persons randomly selected and semi-structured interviews were conducted with some hospital workers. Data analyses were done using SPSS device, QGIS, ARCGIS and GPS for maps building. Our results revealed the presence of faecal coliforms in water samples Bokwango (40 UFC), Small Soppo (90UFC). Also, Salmonella typhi presence in water samples like in Molyko (40), Bokwango (250) and Biaka (600). In addition, typhoid represents 83.89% of waterborne diseases. There is therefore, a strong correlation between bacteriological quality of water consumed and typhoid endemicity in Buea town. Controlling the bacteriological quality of water and adopting sanitation measures is the way forward.

Résumé:

La fièvre typhoïde, maladie hydrique causée par la bactérie Salmonella typhi est un problème majeur de santé publique en Afrique. L'objectif de ce travail est d'examiner la corrélation entre la qualité de l'eau et l'endémicité typhoïdique. Nous avons utilisé l'approche ECOSANTE et l'analyse bactériologique des échantillons d'eau, les entretiens semi-dirigés et l'administration de 200 questionnaires. Les analyses de données ont été effectuées à l'aide des logiciels SPSS, ARCGIS. Les données GPS ont été importées dans ARCGIS pour la confection des cartes. Les résultats montrent la présence de coliformes fécaux dans les échantillons d'eau notamment à Bokwango (40 UFC) et à Small Soppo (90 UFC). La présence de Salmonella typhi a été signalée à Molyko (40), à Small Soppo (240), et à Biaka (600). La typhoïde représente 83,89% des maladies d'origine hydrique. Il existe une corrélation entre la qualité bactériologique de l'eau consommée et l'endémicité typhoïdique dans la ville de Buea.

Keywords / Mots clés

Water, Typhoid, Public health, Buea town
Eau, Typhoïde, santé publique, ville de Buea

Article history/Histoire de l'article
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Introduction

Globally, some 2.2 billion people lack portable water and 1 in 3 people do not have access to safe water (United Nations Funds for Children (UNICEF) and World Health Organization (WHO), 2019). About 785 million people in 2019 lacked portable water and 144 million of them have to use surface water. Hence, the international community has since 2010 recognized that access to quality water and sanitation facilities is a fundamental human right as highlighted in Objective 6 of the Sustainable Development Goals (SDGs) which emphasize access to drinking water and sanitation by 2030.

Availability of good quality water sources nowadays is limited and the impact of pathogens on human health is expected to be significant (Suresh & Smith, 2004). It is therefore essential to understand the contribution of available water sources in the transmission of pathogenic microorganisms in tropical areas particularly in Buea urban space (Cameroon). Typhoid fever, a transmissible disease caused by the bacteria Salmonella typhi (Puran et al. 2009), is an acute, fatal and feverish illness. Without treatment, the case fatality rate is 10-30%, dropping to 1-4% with appropriate therapy (Global Burden of Disease, 2016). Typhoid and paratyphoid fevers occur in both epidemic and endemic form, and remain a major public health problem in underdeveloped countries (DeRoeck, Jodar, & Clements, 2007). The widespread presence of Salmonella in fresh water is evidence that for many years water has been a carrier of Salmonella disease (Kramer, Herwaldt, Craun, Calderon & Juranek, 1996; Jenkins, Endale & Fisher, 2008).

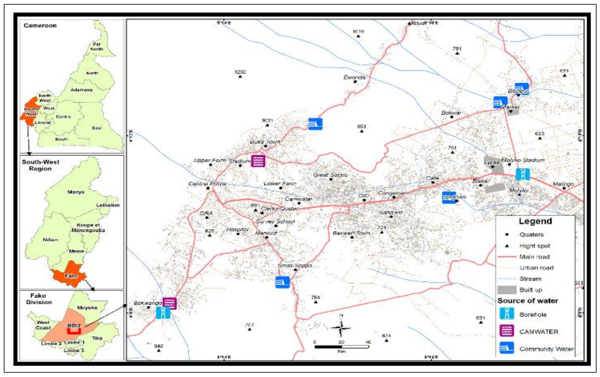
There are an estimated 11-21 million cases of typhoid fever worldwide and an estimated 128,000 to 161,000 deaths annually (WHO, 2018). According to the Mérieux Foundation (2007), it is a disease that kills as many people as cervical cancer and even more than meningitis or Japanese encephalitis. However, it is not mainstreamed as a priority of the World Health Organization (WHO).

Typhoid is a major public health concern in Asia and Africa, which are the centers of high incidence. In Cameroon, access to drinking water and sanitation services is estimated at 3.9% and 34% respectively. According to WHO (2009) and Ndjepel et al. (2014), the epidemiological profile of typhoid is constantly increasing. In Buea city, access to drinking water is a challenge, and promotes typhoid endemicity. Usongo and Aligenui (2021) observed that portable water delivery in Buea is under threat due to the encroachment of human activities posing serious public health problems in Buea. Inspired by this growing crisis of inadequate potable water supply in Buea, this research, therefore, seeks to analyze the correlation between water quality and typhoid endemicity in Buea. Reducing or eradicating this disease will be, a major step forward in the fight against communicable diseases and the achievement of the Sustainable Development Goals (SDGs).

Material and methods

Study area

Buea, the capital of the Southwest Region in Cameroon is situated between latitude 4º 12′ 4º 31′ North of the Equator and longitudes 9º 9′ 9 12′ East. Buea rest at an elevation of 1000 m above sea level on the South-Eastern slopes of Mount Cameroon (Figure 1).



Source: Ediamam Epalle, 2022

Figure 1- Location of the study area showing the sampling points

Bedrock in this area is formed by layers of ash and fine basaltic slag which makes soils extremely conducive to plant growth. In addition, soil structure is fragmentary, nuciform, and grainy with weak cohesion (Sieffermann, 1973). In this evergreen environment where soil porosity is very high, the climate and rainfall pattern are modified by Mount Cameroon which interrupts the movement of air masses from the sea, causing considerable orographic rainfall. According to the classification of Vigneau (2000), the climate of Buea area belongs to that of the well-watered geographical space located north of the equator. Therefore, Buea records an annual rainfall of 3500 mm (IRAD, 1993). Temperatures are considerably high with low annual variations. The mean annual temperature is 23°C while the monthly temperature reveals a minimum of about 20°C in the month of June. As far as population is concerned, besides being the capital of the Southwest Region, Buea is a university and colonial settlement which has grown to attain a population of over 200,000 from 46,000 in 2000 and 90090 people in 2005 (Fombe & Balgah, 2012) and a current population of 300 000 (Buea CVUC, 2019).

Criteria for site and water sources selection

Researchers used a stratified sampling procedure where three main drinking water sources (community water, CAMWATER and boreholes) were identified and ten sampling sites were randomly selected from the three water sources. The criteria used for site selection were; population density and a high dependence on the water sources for domestic and other uses.

Data collection methods, Collection of water samples and Analysis of water quality parameters

The Hypothetico-deductive method and Ecosystem Approach to Human Health (ECOHEALTH) were used in the collection of relevant secondary and primary data for the study. Primary data was collected through direct and indirect observations, structured interviews as well as discussions with resource persons including administrative authorities, institutional actors and traditional healers. A total of 200 questionnaires were administered to household heads in the area. Secondary data was collected from documented sources such as hospital registers of health facilities, the delegation of health as well as from the University of Buea library and the google search engine.

Water samples were collected from the three sources during the dry and rainy season. A Global Positioning System (GPS) was used to take the location of the sampling sites. Water samples were collected using sterilized 500ml glass bottles rinsed with distilled water and dried thereafter. At the collection sites, these bottles were rinsed to eliminate foreign water in the containers. To collect samples from pipe borne water (CAMWATER), the tap was opened and allowed to run for at least one minute. This gave time for the tap to discharge stagnant water in the pipes. The same thing was done with borehole water since it is connected just like pipe borne water. To collect sample from community water (springs), no time was wasted because all the community water sources flowed continuously without being closed. Each sample was codified and transported in an ice-cool container to the laboratory within 24 hours.

Physical and bacteriological analyses of water samples were conducted in the laboratory of the Faculty of Agronomy and Agricultural Sciences of the University of Dschang. Bacteriological quality of water samples was determined by quantitative analysis of E. coli in Sterile Mac Conkey Broth using Most Probable Number (MPN) technique and qualitative determination of salmonella (Munge, 2009). The idea was to distribute 100 ml of water sample (10 ml, 1 ml and 50 ml) in sterilize bottles . Most probable number of coliform bacteria in 100 ml of water samples was estimated. To test salmonella, an agar plate was prepared from SS (salmonella) agar following manufacturer's instructions (Katte et al.2005).

Results

Indicators of faecal contamination

Physical characteristics

During the rainy season, all water sources appeared clean and clear except for the community water in Bokwai and Bweteva, and CAMWATER in Bokwaongo and Bonaberi Street which were clear but contained tiny whitish debris. During the dry season, all sources of water appeared clean and clear except the community water in Vasingi and Biaka and CAMWATER in Bokwaongo and Bonaberi Street which were clear but contained tiny whitish debris. All drinking water sources were colorless and odorless in both seasons. This is because water sources were not polluted by waste or soil particles.

Bacterial characteristics

Bacteriological analysis was carried to determine the most probable number of feacal coliform bacteria (E. Coli) in sterile Mac Conkey Broth and the results are presented on Table 1.

Source	Rainy season		Dry Season	
	Number of fecal Coliforms/ 100ml	Fecal category	Number of fecal Coliforms/ 100ml	Fecal category
Borehole in Molyko	30	C	50	C
Community water in Small Soppo	40	C	2	B
Community water vasingi	35	C	14	C
Camwater in Bokwaogo	90	C	0	A
Camwater in Bokwaogo Bonaberi street	0	A	30	C
Community water in Biaka	3	B	180+	D
Community water in Bokwai	160	D	3	B
Community water in Bwiteva	180+	D	3	B
Boreholes in Bokwaongo	20	C	17	C

Source: Eleme 2021

Table 1: Bacterial concentration in different water sources in Buea urban area during the rainy and dry season and their various classifications according to WHO, 2006

- Faecal bacteria indicator (Faecal coli form):

Results showed that during the rainy season, no concentration of faecal coliforms were found in the CAMWATER source in Bonaberi Street and it was regarded as A-Excellent (No risks), while water sample from the community water in Biaka was regarded as B-Acceptable (Low risk). Samples from borehole in Molyko and Bokwaongo and community water in Vasingi, Small Soppo and Bonduma were regarded as C-Unacceptable (High risk). Samples from CAMWATER in Bokwaongo, community water sources in Bokwai and Bwiteva were regarded as D-Unaccepted (Grossly polluted).

In the dry season, the bacterial concentration of CAMWATER in Bokwaongo was A-Excellent (No risks), the community water sources in Small Soppo, Bwiteva, Bokwai and Bonduma were regarded as B-Accepted (Low risk). Samples from boreholes in Molyko and Bokwaongo and community water in Vasingi and CAMWATER in Bonaberi Street were regarded as C-Unacceptable (High risk) and the community water source in Biaka was regarded as D-Unacceptable (Grossly polluted). Bacteriological analyses showed that faecal coliforms were present in water samples in both seasons.

Specific pathogens

Qualitative and quantitative analysis of salmonella isolates from water samples (culture in SSA) are presented on Table 2.

Source	RAINNY SEASON		DRY SEASON	
	Identified isolates		Salmonella colonies identified isolates	
Borehole in Molyko	40	salmonella para typhi	70	salmonella enteridis/salmonella typhis
Community water in Vasingi	150	salmonella para typhi	15	salmonella enteridis /salmonella typhis
Community water in Small Soppo	240	salmonella paratyphi/ salmonellatyphi	0	salmonella paratyphoid
Community water in vasingi	150	salmonella para typhi	15	
Camwater in Bokwaogo	250	salmonella para typhi, typhi, S, enterotidis NiL	0	
Camwater in Bonaberi steet	0	NIL	27	salmonella enteridis/salmonella typhi/salmonella paratyphi A
Community water in Biaka	11	Salmonella paratyphi,S, typhi	600	Salmonella enteridis
Community water in Bokwai	320	Salmonella paratyphi,S, typhi	0	salmonella enteridis/salmonella typhi/ salmonella paratyphi A
Community water in Bwiteva	400	Salmonella Paratyphi,S, typhi, S,enterotidis	0	
Community water in Bonduma	20	Salmonella para typhi	10	salmonella typhi/salmonella paratyphi/salmonella paratyphy A
Borehole in Bokwaongo	25	Salmonella para typhi	15	salmonella enteridis/salmonellatyphi/salmonella paratyphi A

Source: Eleme 2021

Table 2: Salmonella bacteria in water sources in the Buea urban area during the rainy and dry season

During the rainy season, E. coli and Salmonella typhi were present within water sources at nine sites examined except CAMWATER in Bonaberi Street. In the dry season, Salmonella typhi was present within six sites. Exceptions were community water in Bwiteva, Bokwai and Small Soppo and CAMWATER in Bokwaongo (Table 3).

	RAINY SEASON				DRY SEASON			
	Colony 1	Colony 2	Colony 3	Colony 4	Colony 1	Colony 2	Colony 3	Colony 4
Gram	-ve bacilli	-ve bacilli	-ve bacilli	- ve bacilli	-ve bacilli	-ve bacilli	-ve bacilli	-ve bacilli
Stain								
Catelase	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
Kai								
Medium								
Slope	R	R	R	R	R	R	R	R
Butt	Y	Y	Y	Y	Y	Y	Y	Y
H 2 S	+ weak	-	+	+weak	+weak	-	+	+weak
Glucose	+	+	+	+	+	+	+	+
Lactose	-	-	-	-	-	-	-	-
Sucrose	-	-	-	-	-	-	-	-
Identified	Salmo nella	Salmo nella	Salmo nella	Salmo nella	Salmo nella	Salmo nella	Salmo nella	Salmo nella
Isolate	typhi	typhi	typhi	typhi	typhi	typhi	typhi	typhi
Motility	+	+	+	+	+	+	+	+
Oxydase	-	-	-	-	-	-	-	-
Citrate	-	-	-	-	-	-	-	-
Indole	-	-	-	-	-	-	-	-
Urea	-	-	-	-	-	-	-	-
Gas	-	+	±	-	-	+	±	-

+ = presence, - = absence

Source: Eleme 2021

Table 3: Purification of colonies by sub culturing on ssa and identification of different isolates (using Gram Staining, Catalase and Biochemical Testing)

Typhoid prevalence within the Buea urban area

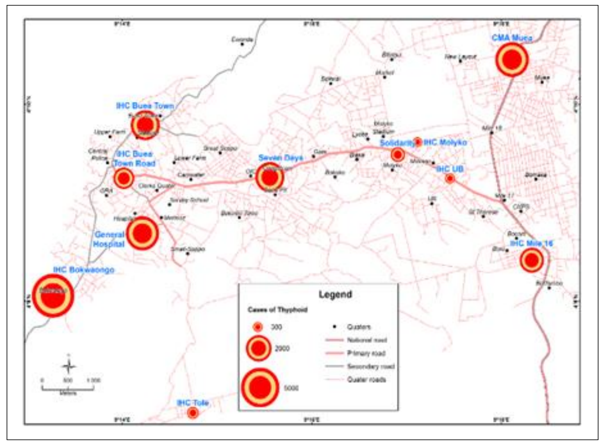
The study considered diseases linked to pathogenic agents, bacteria and protozoa (Viland et al. 2001). The said diseases are presented in the table 4 below.

From table 4 above, it is observed that typhoid is the most prevalent waterborne disease in the Buea urban area with 83.89%, followed by dysentery with 14.18%, diarrhea with 1.92% and cholera with 0.002%. The distribution of typhoid within the Buea urban area is presented on Figure 2.

Name Of Hospital	Dysentery	Typhoid	Diarrhea	Cholera
General Hospital	3608	66718	669	2
Sub Divisional Hospital Muea	3693	10021	639	1
Seven Day Adventist	2783	20222	679	0
Solidarity Hospital	643	2877	41	0
Ihc Bokwoango	5945	14727	650	0
Ihc Buea Town Road	1405	3141	57	0
Ihc Buea Town	2751	10181	176	0
Ihc Molyko	287	5310	53	1
Ihc Mile 16 Bolifamba	1939	3890	195	0
Ihc Bokova	786	6910	78	0
Ihc Ub	317	642	42	0
Ihc Tole	446	888	77	0
Total	**24603**	**145527**	**3356**	**4**

Source: Eleme 2021

Table4: Records of typhoid and other waterborne diseases in the Buea urban area (2009-2019)

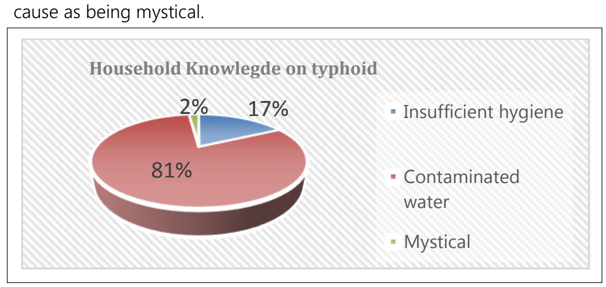


Source: Eleme 2021

Figure2: Distribution of typhoid cases in the Buea urban area

Based on results from hospitals records, cases of typhoid varied from one hospital to another. The IHC in Bokwaongo had the highest cases of typhoid (5000) in the Buea urban area and, IHC in UB the lowest number of typhoid cases (300). The causes of typhoid are well known by the households. The knowledge of household members on the causes of typhoid was sought and the results are seen on Figure 3.

In fact, 81% of households were of the view that typhoid is caused by contaminated water; 17% identified poor hygiene and 2% attributed the cause as being mystical.



Source: Eleme 2021

Figure 3: Household Knowledge on typhoid

Frequency of typhoid in households

Typhoid frequency within households in Buea urban was determined and the results presented on Table 5.

Options	Frequency	Percentage (%)
Every month	21	10.5
Twice a month	8	4
Every three months	53	26.5
Every six months	82	41
Once a year	2	1
Every year	6	3
No idea	4	2
No response	24	12
	200	100

Source: Eleme 2021

Table 5: Frequency of typhoid

From Table 5, 10.5% respondents were of the opinion that, people get sick of typhoid every month, 26.5% said every three months, 41% every six months and 1% indicated once a year.

Discussion

Bacteriological analyses revealed the presence of salmonella typhi for the borehole in Molyko was 30/C-Unacceptable (High risk); Community water in Small Soppo, 40/C-Unaccepted (High risk); Community water in Vasingi-Buea;35/C-Unaccepted (High risk), community water in Bonduma 10/C-Unacceptable (High risk). Almost all water samples collected from CAMWATER Bokwango, presented a risk. The presence of salmonella typhi is a risk factor to typhoid occurrence. This result is in line with studies relating to typhoid fever outbreaks, and epidemiological studies on risk factors for typhoid fever in Asia which have confirmed the association between this disease and the use of poor water quality (Gasem et al., 2001; Sharma et al., 2009; Srikantiah et al., 2007; Tran et al., 2005). Epalle, 2018, while studying waterborne diseases in Santchou town also attested that the presence of salmonella typhi in water sources, was the main cause of typhoid in the area. The presence of Salmonella typhi in the water sources and sampling sites explain the prevalence and endemicity of typhoid in Buea town. Indeed, from the results obtained, typhoid represents 83.89% of waterborne diseases, followed by dysentery 14.18%, Diarrhea 1.93% and cholera 0.002%. The presence of these pathogens in these water sources is in line with studies conducted by (Kramer, Herwaldt, Craun, Calderon, & Juranek, 1996); Jenkins, et al. (2008) argued that the widespread presence of Salmonella in fresh water is an indication of the fact that, for many years water has been a carrier of Salmonella bacteria.

Outbreaks of disease caused by Salmonella in water provide evidence that the presence of Salmonella strains in environmental sources influences human health (Corby et al. 2005; Safranek et al., 2009; Van Houten et al., 1998). In addition, reports on typhoid and paratyphoid fever epidemics in Asia consistently indicate that contamination of well water (Farooqui et al., 2009), running water (Bhunia et al., 2009; Kim et al.., 2003; Lewis et al., 2005; Mermin et al., 1999) and unboiled spring water (Swaddiwudhipong & Kanlayanaphotporn, 2001) was the main source of outbreaks. Overall, the occurrence of diarrheal disease in low income countries has been associated with a wide variety of faecal pathogens, such as rotaviruses, pathogenic strains of Escherichia coli, Vibrio cholerae, Shigella spp., Salmonella enterica serotype Typhi, hepatitis E virus and soil transmitted helminths (Schwarzenbach et al. 2010; Afema et al., 2016; Freeman et al ... 2017). In addition to this, most of the articles (Kim, 2010; Lewis et al., 2005; Mermin et al., 1999; Swaddiwudhipong & Kanlayanaphotporn, 2001) clearly show the involvement of MDR typhoid strains in waterborne epidemics. Typhoid is rife throughout the year in the Buea town. However, it is in the rainy season that it is more aggressive with 59. 62% of cases recorded. This is due to the fact that recurrent torrents promote the transport of pathogenic germs, especially Salmonella, from one water source to another. Rainwater and irrigation water can seep into the soil or run off. Bacteria have been shown to enter both groundwater and surface water during flooding (Gentry et al., 2007; Goss & Richards, 2008; Joy, Lee, Reaume, Whiteley & Zelin, 1998; Stoddard, Coyne and Grove, 1998; Unc and Goss, 2003; Vinten et al., 2002).

In addition, stagnant and persistent ponds are factors of vulnerability to typhoid because they provide sites of exposure to pathogens and constitute reproduction sites for anthropoid vectors (Lall et al. 2016). Poor stormwater drainage can lead to flooding that can damage water supply or sanitation infrastructures. Additionally, where drainage and sanitation are inadequate, runoff can carry fecal matter through the soil and contaminate drinking water sources (Ngugi et al. 2017) posing a risk factor.

During the rainy season, in the study area, fruits abound, the Buea dwellers often consume these fruits without washing them or washing them with salmonellae water, because untreated, potential source of typhoid contamination. There is a potential for contamination of fresh agricultural produce by pathogens (Franz and van Bruggen, 2008; Holden, Pritchard and Toth, 2009; Teplitski, Barak and Schneider, 2009; Berger et al. 2010; Critzer et al. 2010; Critzer et al. Doyle, 2010, Epalle, 2022). The consumption of food irrigated by wastewater in some cases poses health risks since it can be the vector of pathogens associated with excreta, including the bacteria responsible for typhoid fever, Salmonella typhi (Bos et al. 2011; WHO, 2012; Epalle 2022).

Conclusion

Results of the bacteriological analyzes of water samples collected show a hyper presence of faecal coliform, also Salmonella typhi in water samples and a strong correlation between bacteriological quality of water consumed by the population and typhoid endemicity in the Buea town. This study reveals that typhoid endemicity, is a real obstacle to the achievement of the Millennium Development Goals (MDGs) and the Health Sector Strategy (SSS) in Cameroon. Typhoid is a real public health problem in Buea town. Solving this endemicity involves treating water sources before consumption. Households must be trained in water purification techniques before consumption. In addition, the environment must be sanitized and hygiene respected. Controlling the bacteriological quality of water and adopting sanitation measures is the way forward.

References

Aaron P. Jenkins, Stacy D. Jupiter, Adam Jenney, Varanisese Rosa, Alanieta Naucukidi, Namrata Prasad, Gandercillar Vosaki, Kim Mulholland, Richard Strugnell, Mike Kama, John A. Crump and Pierre Horwitz (2019). Environmental Foundations of Typhoid Fever in the Fijian Residential Setting. International journal of environmental research and public health.16, 2407; doi:10.3390/ijerph16132407. www.mdpi.com/journal/ijerph.

Afema, J. A., Byarugaba, D. K., Shah, D. H., Atukwase, E., Nambi, M. & Sischo, W. M. (2016). Potential sources and transmission of Salmonella and antimicrobial resistance in Kampala, Uganda. PLoS ONE 11 (3), e0152130. https://doi.org/10. 1371/journal.pone.0152130

Akullian, A.; Ng'eno, E.; Matheson, A.I.; Cosmas, L.; Macharia, D.; Fields, B.; Bigogo, G.; Mugoh, M.; John Stewart, G.; Walson, J.L.; et al (2015). Environmental transmission of typhoid fever in an urban slum. PLoSNegl. Trop. Dis., 12, e0004212.

Anthony Marius Smith (2018): The Burden of Typhoid Fever in South Africa: The Potential Impact of Selected Interventions. The American Journal of Tropical Medicine and Hygiene 99 (3 SUPPL).

Aubry P. (2013). Les salmonelloses. Médecine tropicale. 6p. Texte revu le 15/12/2013.

Baker, S.; Holt, K.E.; Clements, A.C.A.; Karkey, A.; Arjyal, A.; Boni, M.F.; Dongol, S.; Hammond, N.; Koirala, S.; Duy, P.T.; et al. (2011). Combined high-resolution genotyping and geospatial analysis reveals modes of endemic urban typhoid fever transmission. Open Biol., 1, 110008.

Bula, M., Odio W., Kashongwe K., Mizerero M. (1993). Les aspects épidémiologiques de la fièvre typhoïde à Kinshasa: A propos de 208 observations. Médecine d'Afrique Noire, 6 p.

Carol Dersarkissian (2017): Typhoid Fever. WebMD, LLC. All rights reserved.

Crump JA, Mintz ED (2010): Global Trends in Typhoid and Paratyphoid Fever. Clin Infect Dis. 50(2):241-6.doi: 10.1086/649541 [PMC free article] [PubMed] [Google Scholar].

Communicable Diseases Communique (2017): Typhoid Fever in South Africa. Centre for Enteric Diseases, NICD-NHLS; Division of Public Health Surveillance and Response, NICD-NHLS; Outbreak @nicd.ac.2a, Vol. 16(1).

DeRoeck, D., Jodar, L., & Clements, J. (2007). Putting typhoid vaccination on the global health agenda. The New England Journal of Medicine, 357(11), 1069–1071.

De Alwis, R.; Watson, C.; Nikolay, B.; Lowry, J.H.; Thieu, N.T.; Van, T.T.; Ngoc, D.T.; Rawalai, K.; Taufa, M.; Coriakula, J.; et al. (2018).Role of environmental factors in shaping spatial distribution of Salmonella enterica serovar Typhi, Fiji. Emerg. Infect. Dis., 24, 284.

Dewan AM, Corner R, Hashizume, Ongee (2013): Typhoid Fever and its Association with Environmental Factors in the Dhaka Metropolitan Area of Bangladesh: a Spatiall and Time-Series Approach. PLoD Neglected Tropical Diseases. 7(1).

Djeuda Tchapnga (H.B), Tanawa (E), Ngnikam (E), (2002). L'eau au Cameroun. Tome1: Approvisionnement en eau potable. Yaoundé, Presses Universitaires de Yaoundé, 359 p.

Dorier April E. (1993). Environnement et santé à Brazzaville (Congo): de « l'écologie urbaine » à la géographie sociale. Thèse de doctorat de Géographie, Université de Paris X-Nanterre, janvier 1993. 681 p.

Ediamam Epalle G.M (2018): Les paradoxes de l'Eau et les risques de santé publique dans un fossé d'effondrement: la plaine des Mbos (Ouest-Cameroun). Thèse de Doctorat /PhD. 324 p. Université de Dschang.

Ediamam Epalle G.M (2022): Eau, endémicité typhoïdique et problème de santé publique dans les villes de Kékem et de Santchou (Ouest–Cameroun). In de la croissance urbaine à l'aménagement du territoire, Editions du MIDI.

Farooqui, A., Khan, A., & Kazmi, S. U. (2009). Investigation of a community outbreak of typhoid fever associated with drinking water. BMC Public Health, 9(476), doi:10.1186/1471-2458-9-476

Freeman, M. C., Garn, J. V., Sclar, G. D., Boisson, S., Medlicott, K., Alexander, K. T., Penakalapati, G., Anderson, D., Mahtani, A. G., Grimes, J. E. T., Rehfuess, E. A. & Clasen, T. F. (2017). The impact of sanitation on infectious disease and nutritional status: a systematic review and meta-analysis. International Journal of Hygiene and Environmental Health 220 (6), 928–949. https://doi.org/10.1016/j.ijheh.2017.05.007

Fondation Mérieux (2007). Le colloque sur la fièvre typhoïde : un premier pas vers l'élaboration des recommandations mondiales de vaccination. In www. Fondation-mérieux.org

Fombe L.F & Agbortoko M.A.N (2014). Housing Standards, Household Health and Disease Nexus in the Buea Municipality Journal of Sustainable Development, Vol.7, No.4; Canadian Center of Science and Education. URL: http://dx.doi.org/10.5539/jsd.v7n4p262

Gasem, M. H., Dolmans, W. M., Keuter, M. M., & Djokomoeljanto, R. R. (2001). Poor food hygiene and housing as risk factors for typhoid fever in Semarang, Indonesia. Tropical Medicine & International Health, 6, 484–490.

Georges C., Decrock C., Cattin B., Collet L., Brettes A., Abdou M. (2010). Typhoïde à Mayotte en 2007-2008. Bulletin épidémiologique hebdomadaire 27/28, 6 juillet 2010, 3 p.

Global Burden of Disease (2016). Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017 ;390 :1151–1210. doi: https://doi.org/10.1016/S0140-6736(17)32152-9

Institut de Veille Sanitaire (2012). Identifier et surveiller les impacts sanitaires du changement climatique pour s'y adapter/ Identify and monitor health impacts of climate change in the context of adaptation. Bulletin de veille sanitaire N°12-20 mars 2012, 16p.

Jamie Bartram et Paul Hunter (2015). Bradley Classification of disease transmission routes for water-related hazards from: Routledge Handbook of Water and Health Routledge https://www.routledgehandbooks.com/doi/10.4324/9781315693606.ch03.

Jenkins, M. B., Endale, D. M., & Fisher, D. S. (2008). Most probable number methodology for quantifying dilute concentrations and fluxes of Salmonella in surface waters. Journal of Applied Microbiology, 104, 1562–1568.

Jenkins, A.P.; Jupiter, S.; Mueller, U.; Jenney, A.; Vosaki, G.; Rosa, V.; Naucukidi, A.; Mulholland, K.; Strugnell, R.; Kama, M.; et al. (2016). Health at the sub-catchment scale: Typhoid and its environmental determinants in Central Division, Fiji. EcoHealth, 13, 633–651.

Jonathan, C, Marlies C, David, S. et Brian, S. (1999) Mapping malaria risk in the highlands of Africa. Epidemiology of High land malaria project and Mapping malaria risk project in Africa and Collaboration.

John, L. Brusch (2019): Typhoid Fever. Consulting Staff, Department of Medicine and Infectious Disease Service, Cambridge Health Alliance.

Global Hydration (2018): Common Waterborne Disease, Bacteria, Viruses and Cysts. Copyright © 2018 Global Hydration. All Rights Reserved.

Karkey, A, Jombart T, Walker AW, et al (2016): the Ecological Dynamics of Fecal Contamination and Samonella Typhi and Samonella Paratyphi A in Municipal Kathmandu Drinking Water. PLOS Negl Trop Di, 10: e0004346.

Katte Fonge N. (2020): Water Samples in the Buea Municipality, Cameroon. Animal Physiology and Health Laboratory. Department of Animal Science-FASA, University of Dschang.

Kim, S. (2010). Salmonella serovars from foodborne and water-borne diseases in Korea, 1998–2007: Total isolates decreasing versus rare serovars emerging. Journal of Korean Medical Science, 25, 1693–1699.

Lall, C.; Kumar, K.V.; Raj, R.V.; Vedhagiri, K.; Vijayachari, P. (2016). Prevalence and diversity of leptospirosis in different ecological niches of urban and rural areas of South Andaman Island. Microbes Environ, 31, 79–82.

Lewis, M. D., Serichantalergs, O., Pitarangsi, C., Chuanak, N., Mason, C. J., Regmi, L. R., et al. (2005). Typhoid fever: A massive, single-point source, multidrug-resistant outbreak in Nepal. Clinical Infectious Diseases, 40(4), 554–561

Mansotte F., Ravacholl F., Ardillon V., Flamand C., Maison D., Marion N. (2009). Épidémie de typhoïde en Guyane française : treize ans de veille et de gestion sanitaires. Bulletin de veille sanitaire N°9/septembre 2009, 4 p.

Nguendo B., Salem G., Bruneau J-C. (2008). Épidémiologie géographique des maladies diarrhéiques à Yaoundé. Vol N°89 (1-2008), in mappemonde.mgm.fr

Ngugi, H.N.; Home, P.G.; Mutwiwa, U.N. (2017). Impacts of water and sanitation activities on the environment in the Upper Mara Basin. Civ. Env. Res., 6, 9–16.

Organisation Mondiale de la Santé (2018). Vaccins anti typhoïdiques : note de synthèse de l'OMS. Épidémiologique hebdomadaire. 2018 ; 93(13):153-72.(http://apps.who.int/iris/bitstream/handle/10665/272272/WER9313.pdf?ua=1).

Ps-eau (les Agences de l'eau) (2013). Les enjeux de l'eau et de l'assainissement au Cameroun. Fiche pays: Cameroun.2pp.

Puran K, Ramakrishnan R, Hutin Y, Manickam P. and M. D. Gupte (2009). Risk factors for typhoid in Darjeeling, West Bengal, India: evidence for practical action. Tropical Medicine and International Health. Volume 14 no 6 pp 696–702.

Suresh, K., & Smith, H. V. (2004). Tropical organisms in Asia/Africa/South America. In J. A. Cotruvo, A. Dufour, G. Rees, J. Bartram, R. Carr, D. O. Cliver, G. F. Craun, R. Fayer, & V. P. J. Gannon (Eds.), Water-borne zoonoses identification, causes, and control (pp. 93–112). London: IWA Publishing, World Health Organization.

Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., von Gunten, U. & Wehrli, B. (2010). Global water pollution and human health. Annual Review of

Environment and Resources 35 (1), 109–136. https://doi.org/10.1146/annurev-environ-100809-125342

Tita, M.A, (2008). Water pollution of the Nkoup river system and its environmental impact in Foumbot (Western Cameroon). Thèse Doctorat/ PhD 212 p. Université de Yaoundé I.

Usongo, P. Ajonina and Briyan Aligenui (2021). An Assessment of the Spatio Temporal Dynamics of Potable Water Delivery for Water Resource Management on the South Eastern Flank of Mount Cameroon. Int J Environ Sci Nat Res Volume 28 Issue 3 - June 2021

Vigneau, J.-P. (2000). Géoclimatologie. Ellipse, Paris, 334 p.

Viland M, Montiel A, Duchemin J, Larivière M, Zarrabi P, (2001). Eau et Santé. Guide pratique pour les intervenants en milieu rural Africain. Ps-Eau. Edition du Grete. 114 P.

Vijayalaxmi, V. Mogasale, EnusaRamani, Vittal Mogasale, & Ju Yeon Park (2018): estimating Typhoid Fever Risk Associated with Lack of Access to Safe Water: A Systematic Literature Review, Journal of Environmental and Public Health (6):1-14.

Vollaard, A.M.; Ali, S.; van Asten, H.A.; Widjaja, S.; Visser, L.G.; Surjadi, C.; van Dissel, J.T. (2004). Risk factors for typhoid and paratyphoid fever in Jakarta, Indonesia. JAMA, 291, 2607–2615.

WHO (2006). Guide lines for Drinking Water Quality: Incorporating First Addendum. Vol 1, Recommendations-3rd ed.

WHO (2018): Typhoid Vaccines: WHO Position Paper. WKLY Epidemol//apps.who.int/iris/bit stream/handle/10665/272272/WER.

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