Determination of Faecal Contamination of the Groundwater Resources from Tano Districts of Ghana

Frank Awuah,
Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
Department of Science, Abetifi Presbyterian College of Education, Abetifi-Kwahu, Ghana.
Robert Clement Abaidoo,
Kingsley Badu,
Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Doi:10.19044/esj.2020.v16n24p173 URL:http://dx.doi.org/10.19044/esj.2020.v16n24p173

Abstract

This paper seeks to report on whether there are faecal contaminants in the groundwater resources within the Tano Districts, where people use groundwater as their source of drinking water and for other domestic purposes. Total Coliforms, Faecal Coliforms, Enterococci, E.coli and Salmonella were employed as faecal indicators in this study. Determination of these faecal indicators in the samples was done using the Most Probable Number (MPN) method. A simple random sampling method was employed to get the sample size of 15 wells. The results of this study indicate that the water in the selected wells had faecal contaminants, proved by the presence of the faecal determinants in the water samples collected The presence of these organisms is an indication that water within the wells from the study area has been faecally contaminated with animal or human faeces. These bacteria are used as faecal indicators as an evidence of possible sewage contamination because, they are commonly found in animal or human faeces. Therefore, the fact that these faecal indicators have been detected in water sampled from the selected wells means that pathogens might also be present. The study recommends treatment of the groundwater supplies or encourages the use of the home water treatment.In an attempt to solve the problem of the faecal contamination of the selected wells, a future research should be conducted to determine the source of faecal contamination of ground water in wells at the Tano Districts.

Keywords: Total Coliform, Enterococci, Faecal Coliformcontaminants, Groundwater

Introduction:

Improving water services and uses are essential for increasing hygiene and sanitation, which have a repercussion on the productive lives of people. Health, nutrition and food production are dependent on availability of water in adequate quantities and good quality.

According to WHO (2001), it is a Millennium Development Goal to increase the number of people who gain access to safe drinking water. Paying attention to appropriate monitoring and quality analysis of water sources in developing countries, this goal could be accomplished.

Ferrer et al (2020) observe that groundwater has the potential of being the major source of drinking, domestic water supply and for ecosystem maintenance as a whole (Lapworth and Sorensen, 2018; Li and Qian, 2018; Li et al., 2018).

However, not all the groundwater is safe for human consumption (Zhai et al., 2015; MacDonald et al., 2016; Vunain et al., 2020; Healy et al., 2017; Foster et al., 2019; Wang et al., 2018; Jia, 2019). Both shallow Phreatic and deep confined aquifers have been subjected to deterioration and in this case destroying the quality of the groundwater (Xiao et al., 2017a ; Chuah and Ziegler, 2018).

From the perspective of (Takal and Quaye-Ballard, 2018; Kapembo et al., 2019), groundwater could be faecally deteriorated as a result of developmental activities and this raises questions about its suitability for drinking and for domestic purposes. The area under study in this research is no exception of these developments.

In the study conducted by Kayembe et al. (2018), it was indicated that majority of isolated Faecal indicator bacteria strains were of human origin, pointing out the effect of poor household sanitation practices on not only surface water but also on groundwater.

There is therefore a refutation of the general assumption that water passing through the soil was purified by active microbial process and by filtration. Groundwater environment is seen not devoid of life as previously it was commonly perceived. As groundwater contamination becomes more and more evident, there should be the motivation for understanding groundwater environment.

It must be pointed out that this faecal contamination of groundwater resources can subject human lives to the risk such as gastroenteritis. Contamination of groundwater is a leading cause of diarrhoeal diseases (Maramraj et al., 2020; Díaz-Alcaide and Martínez-Santos, 2019). To determine this contamination, one needs to know that, faecal indicator or faecal bacteria have a correlation with the microbial risk posed by groundwater faecal contamination (Ercumen et al., 2017; Pakistan Nabeela et al., 2014; Nabeela et al., 2014; Kayembe et al., 2018). This is a discovery many residence in the Tano Districts of Ghana seem ignorant. Ahmad et al. (2020), states that People are using groundwater and at the same time ignorant about its suitability for drinking and domestic purposes. This ignorance and the risk of groundwater contamination are what must be of a greater concern to both the environmental Scientist and the Microbiologist in the protection of the human species in addressing this problem of contamination. Groundwater quality should be of a concern because it influences human health and social-economic development (Xiao et al., 2019).

In Tano Districts of Ghana, where this study was conducted, the people mainly use groundwater as a source of domestic water and for other purposes. Recent reports from the Tano North District Health Directorate (2011) indicate that many people in the Districts complain of typhoid and other diarrhea related diseases. The information indicated that in the year, 2009, 656 people in the District reported on diarrhoea related diseases. This increased to 1013 in 2010 and 1020 in 2011. The report also showed that most of these people are inhabitants of the Zongo community where the people use wells as the main sources of water for domestic purposes.

Yet there is an information gap in the faecal contamination of the wells in the Tano Districts of the Republic of Ghana and hence the need for this study.

Methodology

Study Area

The area under study is made of Tano North District and Tano South District jointly referred to as Tano Districts in this paper. Duayaw Nkwanta and Techire are in the Tano North whilst Tehimantia is within the Tano South District. This study area falls in the granite metasediment belt, with mainly clayey soil and hence have greater capacity in retention of water for plant use (District profile, 2010 in Awuah, 2012).

These Districts under consideration lie in the semi-equatorial climatic zone with double maximum rainfall. The major rainfall season is from March to July while the minor season is experienced between September and November. The area has a mean annual rainfall of about 1250 mm. The mean temperature of these Districts is relatively 26-30 degrees Celsius with humidity of 75-80%. The temperature conditions in these areas promote the cultivation of tropical crop such as cocoa, plantain, cassava, palm oil and maize. The people in this area rely mainly on hand dug wells, boreholes and pipe borne water for domestic purposes.

This area falls within the high topographical areas of the country with elevation in most parts above 270 m. The landscape is generally with average height of about 380 m with the highest elevation ranging between 360 m to760 m above sea level

Report from the Tano North planning unit, 2010 census indicates that, Duayaw Nkwanta has a population of 16,541 and that of Techire is 4,608. From the 2010 population census, the population of Techimantia is 10,800. The maps of Tano North and south are shown below

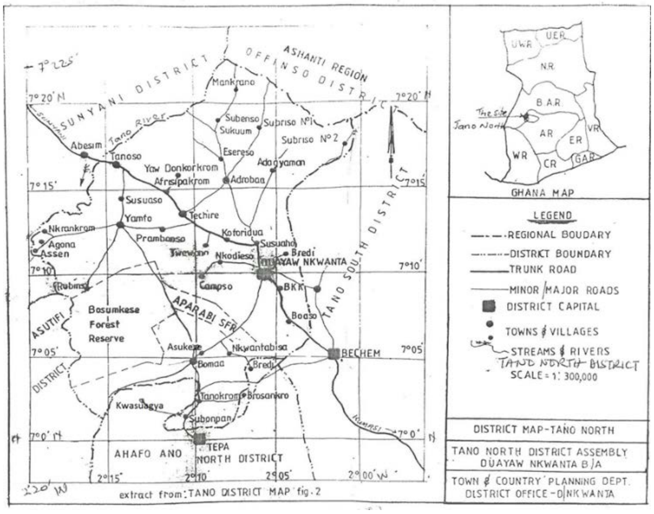

Fig 1: District Map – Tano North

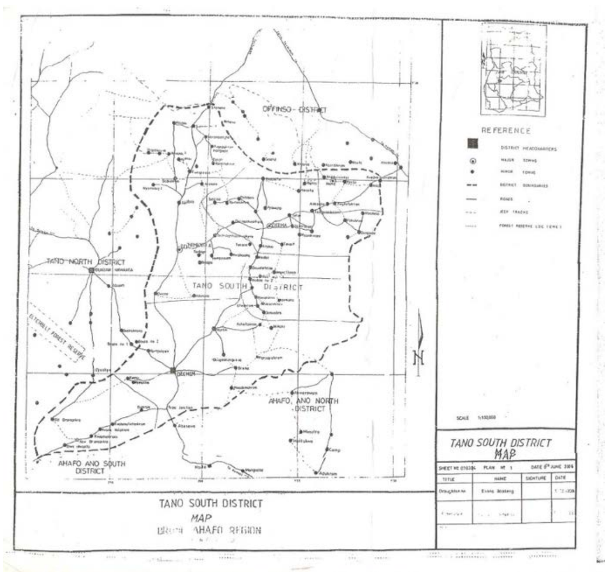

Fig 2: District Map – Tano South

Data Collection

The study considered hand-dug wells and borehole water samples as the main experimental materials. In all, five boreholes and ten hand dug wells were selected randomly for the study.

2-liter hard plastic and screw capped bottles that have been sterilized were used to collect the water samples. In all four samples were taken intermittently from each well. The samples were sent within 2 hours of collection in a cool box containing ice packs to the Science Laboratory of Department of Theoretical and Applied Biology of the Faculty of Bioscience, Kwame Nkrumah University of Science and Technology for analysis.

Sampling Procedure

To obtain the sample size, simple random sampling method was employed. In this method, 01 to 160 representing the total number of wells in the study area was written on pieces of paper and placed in a box. The papers were then shaken vigorously and were raised beyond the eye level. The researcher then selected one piece of paper at a time and the number on it recorded as a site where well water was to be sampled. To see to it that each piece of paper had equal and independent chance of being included in the sample, the selected piece of paper in each case was put back into the box to ensure that in each time of picking there was 160 pieces of paper in the box. This was repeated until fifteen wells were selected to represent the area under study.

Laboratory Procedures

Faecal and Total Coliforms

Determination of the total and faecal coliforms in the samples was done using the Most Probable Number (MPN) method. In the Serial dilutions, 10^{-1} and 10^{-11} were prepared by picking 1ml of the sample into 9ml sterile distilled water. From each dilution, one milliliter aliquot was inoculated into 5ml of MacConkey Broth (1:5) with inverted Durham tubes and incubated at 35^{oC} for total coliforms and 45^{oC} faecal coliforms for 18- 24 hours. Tubes with colour change from purple to yellow and gas collected in the Durham tubes after 24 hours were identified as positive for both total and faecal coliforms. Counts per 100ml were calculated from the appropriate Most Probable Number (MPN) tables.

E coli

A drop was transferred into a 5ml test tube of tryptone water from each of the positive tubes identified and was then incubated at a temperature of 44^{oC} for a duration of 24 hours. This was followed by the addition of a drop of Kovacs' reagent to the tube of tryptone water. Tubes which showed a red ring colour development after gentle agitation indicated the presence of indole and were taken as presumptive for *E coli* (themotolerant coliforms). Counts per 100ml were calculated from Most Probable Number (MPN) tables.

Salmonella

Prepared 10ml of manufactured formula of buffered peptone water (BPW) was in a universal bottle and serial dilution of 1ml sample added to it. This was incubated at a temperature of 37^{oC} for 24 hours. 0.1ml of the sample from the BPW was then placed in a 10 ml of serenity broth in universal bottle and incubated at 44^{oC} for 48 hours. Swaps were transferred from the bottle unto SS agar and incubated at 48 hours at 37^{oC}. Here, the absence of black colonies on the SS agar indicated the absence of salmonella.

Faecal Enterococci

Preparation of Serial dilutions of 10^{-1} to 10^{-11} was done by picking 1 ml of the sample into 9 ml sterile distilled water. One milliliter aliquots from each of the dilution were inoculated on a Slanetz and Barltey Agar prepared on sterile Petri dishes and incubated at a temperature of 37^{oC} for 4 hours to aid bacteria resuscitation. Incubation of the plates was done at a temperature of 44^{oC} for a further 44 hours. All red, maroon and pink colonies that were smooth and convex were counted and recorded as faecal enterococci after the incubation.

Results and Discussion

Faecal Contamination of groundwater

Table1 presents the faecal contamination of groundwater resources in the Tano Districts of Ghana**.**

Table 1: ***Faecal Contamination of groundwater resources***

Location of Wells	Log_{10} Geo mean counts/100ml (n=60)		
	TC	**FC**	**EC**
C 62/4	3.50	2.13	2.55
D 77/3	3.50	1.36	1.60
D 382/3	2. 66	1.80	2.01
D 369/3	3.30	1.50	2.39
D 156/3	3.00	2.00	2.25
D 306/3	4.04	2.80	2.65
D78/3	3.50	2.00	1.93
C 31/3	2.67	1.96	1.93
D45/3	4.02	2.67	2.34
Nurses Qters A	2.04	1.37	1.31
Nurses Qters B	1.37	1.36	1.29

Susuanmu (A)	3.12	0.00	0.00
Susuanmu (B)	5.01	3.79	3.30
Saviour mission A	3.81	2.46	2.14
Saviour mission B	4.73	2.67	2.08

NB: TC = total coliform, FC = faecal coliform, EC = enterococci

In Table1, the water collected from the 15 sampling sites were contaminated with Total Coliforms, Faecal Coliforms and Enterococci, with the exception of Susuanmu A which showed only the presence of Total Coliforms.

Mean E.coli counts of log 0.95 and 1.36 were also detected in water samples from locations D306/3 and Susuanmu (B) respectively. There was no detection of Salmonella in all the waters sampled in this study.

The presence of these organisms is an indication that waters within the wells from the study area with the exception of Susuanmu A have been faecally contaminated with animal or human faeces. These bacteria are used as faecal indicators as an evidence of possible sewage contamination. This can be explained in that they are commonly found in human faeces. They are generally not harmful themselves but they indicate the possible presence of pathogens (disease causing organisms) being bacteria, viruses or prokaryotes that live in human and animal digestive systems. Hence, the fact that these faecal indicators have been detected in water sampled from the selected wells means that pathogens might also be present and therefore, anyone who consumes water from these sources might be at health risk.

Contamination of drinking water due to influx of faecal contaminants into groundwater can cause very serious gastrointestinal illness (Lapworth and Sorensen, 2018; Maramraj et al., 2020; Benediktsdóttir et al., 2020; Anjali et al., 2020; Ercumen et al., 2014).

According to WHO guidelines (2004), water should have a value of 0CFU/100 ml in order for it to be considered safe for human consumption. Ercumen et al. (2017) is of the view that faecal indicator or faecal bacteria have a correlation with the microbial risk posed by groundwater source.

Conclusion:

It is concluded from this study that, the water from the selected wells has been faecally contaminated with animal or human faeces with the exception of Susuanmu A. The results have shown that all the groundwater sampled from the study sites did not satisfy the WHO standard for save drinking water. From the perspective of the WHO guidelines (2004), water should have a value of 0CFU/100 ml in order for it to be safe for human consumption.

It is therefore recommended that in an attempt to reduce the risk of groundwater contamination, the following methods must be employed:

- Treat groundwater supplies or encourage the use of the home water treatment.
- Future research is to be conducted to determine the source of faecal contamination of the water in the selected wells within the study area.

Acknowledgement

Glory be unto the Almighty God for how far He has brought us in this study. We must show our heartfelt appreciation to our supervisor, Professor R. C. Abaidoo, the supervisor of this paper for his insightful guidance, invaluable patience and the encouragement during the preparation of this work. We have a good reason for registering our profound gratitude to a brother and Colleague, Dr. Samuel Appah for his support and encouragement during this process. Last but not the least, we wish to appreciate Mrs. Joyce Awuah and the whole of Awuah's family for their unwavering support throughout the time for this study.

References:

1. Ahmad, M. N., Sultana, R., Yoshida, M., & Salahuddin, M. (2020). Groundwater Contamination Issues in Chiniot Area, Punjab, Pakistan. International Journal of Environmental Science and Development, 11(3).
2. Archives (2010), Tano North District Assembly, Brong Ahafo Region, Ghana
3. Awuah, F. (2012). Impact of Pit Latrines on Groundwater in Some Selected Towns in the Tano Districts (Master's dissertation).
4. Benediktsdóttir, E., Gunnarsdóttir, M. J., Ómarsdóttir, B. D., Sigurjónsson, V. Í., & Gardarsson, S. M. (2020). Virus inactivation in groundwater in postglacial lava field in arctic climate. Letters in Applied Microbiology.
5. Chuah, C. J., & Ziegler, A. D. (2018). Temporal variability of faecal contamination from on-site sanitation systems in the groundwater of Northern Thailand. Environmental management, 61(6), 939-953.
6. Díaz-Alcaide, S., & Martínez-Santos, P. (2019). Mapping fecal pollution in rural groundwater supplies by means of artificial intelligence classifiers. Journal of Hydrology, 577, 124006.
7. Ercumen, A., Gruber, J. S., & Colford Jr, J. M. (2014). Water distribution system deficiencies and gastrointestinal illness: a

systematic review and meta-analysis. Environmental health perspectives, 122(7), 651-660. Michel

8. Ercumen, A., Naser, A. M., Arnold, B. F., Unicomb, L., Colford Jr, J. M., & Luby, S. P. (2017). Can sanitary inspection surveys predict risk of microbiological contamination of groundwater sources? Evidence from shallow tubewells in rural Bangladesh. The American journal of tropical medicine and hygiene, 96(3), 561-568.
9. Ferrer, N., Folch, A., Masó, G., Sanchez, S., & Sanchez-Vila, X. (2020). What are the main factors influencing the presence of faecal bacteria pollution in groundwater systems in developing countries?. Journal of contaminant hydrology, 228, 103556.
10. Foster, T., Willetts, J., & Kotra, K. K. (2019). Faecal contamination of groundwater in rural Vanuatu: prevalence and predictors. Journal of water and health, 17(5), 737-748.
11. Gay, R. L. (1992). Educational Research fundamentals for the consumer (2nd Ed). N.Y.;
12. Harper Collins
13. Healy, A., Allan, S., Bristow, G., Capstick, S., Danert, K., Goni, I., ... & Upton, K. (2017, July). Individual water sourcing: understanding risks and resilience to groundwater resource abstraction in Nigeria. In Local action with international cooperation to improve and sustain water, sanitation and hygiene (WASH) services: Proceedings of the 40th WEDC International Conference, Loughborough, UK (pp. 24-28). cc WEDC, Loughborough University.
14. Jia, X., O'Connor, D., Hou, D., Jin, Y., Li, G., Zheng, C., ... & Luo, J. (2019). Groundwater depletion and contamination: Spatial distribution of groundwater resources sustainability in China. Science of The Total Environment, 672, 551-562.
15. Kapembo, M. L., Al Salah, D. M. M., Thevenon, F., Laffite, A., Bokolo, M. K., Mulaji, C. K., ... & Poté, J. (2019). Prevalence of water-related diseases and groundwater (drinking-water) contamination in the suburban municipality of Mont Ngafula, Kinshasa (Democratic Republic of the Congo). Journal of Environmental Science and Health, Part A, 54(9), 840-850.
16. Kayembe, J. M., Thevenon, F., Laffite, A., Sivalingam, P., Ngelinkoto, P., Mulaji, C. K., ... & Poté, J. (2018). High levels of faecal contamination in drinking groundwater and recreational water due to poor sanitation, in the sub-rural neighbourhoods of Kinshasa, Democratic Republic of the Congo. International journal of hygiene and environmental health, 221(3), 400-408.

17. Lapworth, D. J., & Sorensen, J. P. R. (2018). BGS-UKRI briefing note: tryptophan-like fluorescence (TLF) as a rapid in-situ screening tool for assessing faecal contamination risk in groundwater.
18. Li, P., & Qian, H. (2018). Water resources research to support a sustainable China.
19. Li, Z., Wang, G., Wang, X., Wan, L., Shi, Z., Wanke, H., ... & Uahengo, C. I. (2018). Groundwater quality and associated hydrogeochemical processes in Northwest Namibia. Journal of Geochemical Exploration, 186, 202-214.
20. MacDonald, A. M., Bonsor, H. C., Ahmed, K. M., Burgess, W. G., Basharat, M., Calow, R. C., ... & Lark, R. M. (2016). Groundwater quality and depletion in the Indo-Gangetic Basin mapped from in situ observations. Nature Geoscience, 9(10), 762-766.
21. Maramraj, K. K., Subbalakshmi, G., Ali, M. S., Dikid, T., Yadav, R., Sodha, S. V., ... & Singh, S. K. (2020). A community-wide acute diarrheal disease outbreak associated with drinking contaminated water from shallow bore-wells in a tribal village, India, 2017. BMC Public Health, 20(1), 1-8.
22. Maramraj, K. K., Subbalakshmi, G., Ali, M. S., Dikid, T., Yadav, R., Sodha, S. V., ... & Singh, S. K. (2020). A community-wide acute diarrheal disease outbreak associated with drinking contaminated water from shallow bore-wells in a tribal village, India, 2017. BMC Public Health, 20(1), 1-8
23. Nabeela, F., Azizullah, A., Bibi, R., Uzma, S., Murad, W., Shakir, S. K., ... & Häder, D. P. (2014). Microbial contamination of drinking water in Pakistan—a review. Environmental Science and Pollution Research, 21(24), 13929-13942.
24. Takal, J. K., & Quaye-Ballard, J. A. (2018). Bacteriological contamination of groundwater in relation to septic tanks location in Ashanti Region, Ghana. Cogent Environmental Science, 4(1), 1556197
25. Vunain, E., Nkhuzenje, C., Mwatseteza, J., & Sajidu, S. (2019). Groundwater quality assessment from Phalombe plain, Malawi. ChemSearch Journal, 10(1), 1-10.
26. Wang, Y., Song, X., Li, B., Ma, Y., Zhang, Y., Yang, L., ... & Holm, P. E. (2018). Temporal variation in groundwater hydrochemistry driven by natural and anthropogenic processes at a reclaimed water irrigation region. Hydrology Research, 49(5), 1652-1668.
27. WHO/UNICEF, (2004), Joint Monitoring Programme for Water Supply and Sanitation; Meeting the MDG drinking water and sanitation target: a mid-term assessment of progress. Geneva, Switzerland.

28. World Health Organization (WHO). (2001). Water health and human rights, World Water Day.
29. Xiao, Y., Gu, X., Yin, S., Pan, X., Shao, J., & Cui, Y. (2017). Investigation of geochemical characteristics and controlling processes of groundwater in a typical long-term reclaimed water use area. Water, 9(10), 800.
30. Xiao, Y., Yin, S., Hao, Q., Gu, X., Pei, Q., & Zhang, Y. (2020). Hydrogeochemical appraisal of groundwater quality and health risk in a near-suburb area of North China. Journal of Water Supply: Research and Technology—AQUA, 69(1), 55-69.
31. Zhai, Y., Lei, Y., Zhou, J., Li, M., Wang, J., & Teng, Y. (2015). The spatial and seasonal variability of the groundwater chemistry and quality in the exploited aquifer in the Daxing District, Beijing, China. Environmental monitoring and assessment, 187(2), 43.