INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES Volume7, No 1, 2016

Research article ISSN 0976 – 4402

The contribution of water tanker operations to the health of water consumers in Cape Coast Metropolis, Ghana

Eric Awere[1], Geophrey K. Anornu[2]
1- Department of Civil Engineering, Cape Coast Polytechnic, Cape Coast, Ghana
2- Department of Civil Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
eric.awere@cpoly.edu.gh
doi:10.6088/ijcser. 7010

ABSTRACT

The operations of water tankers have become very prominent in the Cape Coast metropolis of Ghana. The services of these operators are patronized by people living in new housing development areas who are not served by Ghana Water Company Limited (GWCL) primarily due to infrastructural challenges. Though these operators obtain their water from a GWCL hydrant, the quality of water they supply have come under serious criticism by some patrons. This research is aimed at assessing the physico-chemical and bacteriological characteristics of water supplied by water-tanker operators. A total of 24 water samples from five (5) water tankers, the GWCL water hydrant and a GWCL customer were collected in the months of January and March for analysis. The samples were analysis for Taste, Odour, Colour, Turbidity, Total Dissolved Solids, Alkalinity, Total Iron, Chloride, Fluoride, Nitrite, Nitrate and E-coli. All analysis was performed according to protocols specified in the Standard Methods for the Analysis of Water and Wastewater. The results showed that water from GWCL met the WHO guidelines. Water from the tankers showed rather poor quality by failing in colour, turbidity, total iron and bacteriological. Contamination could be attributed to improper management of the tankers.

Keyword: Health, Water Consumers, Water quality, water tanker.

1. Introduction

Safe water supply is one of the fundamental requirements for human life. Without water, life cannot be sustained beyond a few days. Access to potable drinking water in adequate quantities is a fundamental human right irrespective of age and socio-economic status (Howard and Bartram, 2003). However, this basic human right is still a luxury for many of the world's poor people (UNEP, 1992). The quality of water consumed by humans is recognized by Howard and Bartram (2003) as an important transmission route for infectious diarrhoeal which is the primary component of the water-related disease burden. An estimated 80% of all diseases and over one-third of deaths in developing countries (about 90% being children under the age of 5 years) (Elimelech, 2006, Nath et al., 2006) are caused through the consumption of contaminated water. Deteriorating water quality also threatens the Millennium Development Goals (MDG) water target of halving the proportion of people without sustainable access to safe water by 2025. Despite modern technology and know-how, waterborne diseases continue to have a major public health and socio-economic impact (Craun, 1991). Water quality is often related to the degree of bacterial contamination (Zamberlan da Silva et al., 2008) and health of consumers (WHO, 2003). On the contrary,

Received on January 2016 Published on July 2016

studies on water quality and consumer perceptions in British Columbia, Canada suggests that taste, smell, colour and particulate matter were rated as the most important water quality indicators by respondents (Magwood, 2005).

The Cape Coast Metropolis (with a population of 169,894 according to 2010 census) receives it water supply mainly from Ghana Water Company Limited (GWCL) through household connections and stand pipes (private and public). The production of water (from surface water impoundment) by GWCL is carried out at the Brimsu treatment plant for distribution to the metropolis. About 80% of the residents in the metropolis get their water supply daily from GWCL. The unserved population, mostly in new housing development areas, resorts to sachet water (popularly called 'pure water'), wells and boreholes and the services of water tanker operators. Water from the wells (groundwater) is salty due to the sea water intrusion while boreholes are too expensive to construct and mechanize by individual houses. Though sachet water is expensive (about US$0.60 per 500ml), most houses depend on it for drinking. For other domestic purposes the only available source of potable water is tanker water services.

Whilst WHO and UNICEF (2006) has classified tanker-supplied water as 'unimproved' and considers them to be unsafe for drinking purposes, Mehta et al. (2007) has reported that governments in many developing countries view tanker water (and other small water providers) as a practical way of serving low-income households and dispersed populations in rural and peri-urban areas. Although some of the tankers may be delivering water obtained from potable sources such as the case of Teshie Water Tanker Operators Association in Accra, Ghana (McGranahan and Owen, 2006) a number of health concerns have been associated with water supplied to consumers by water tankers such as inadequate treatment or transport in inappropriate containers (WHO, 2008). For example tanker water (broadly called Vended water) has been associated with outbreaks of diarrhoea disease (Hutin et al., 2003). WHO (2008) Guidelines for drinking water quality proposes a free residual chlorine concentration of at least 0.5 mg/L after a contact time of at least 30 minutes at the delivery point.

In Cape Coast, water tanker operators obtain their supply from GWCL hydrant located at the Company's premises at Pedu along the Accra – Takoradi Highway. Though this water may have been treated to acceptable standards, the water delivered to consumers by these tankers have come under serious criticism primarily due to the physical appearance the water deliver. Furthermore, data from the Central Regional Health Directorate of the Ghana Health Service in Cape Coast revealed that about 39,828 cases of water – related diseases were recorded in the Cape Coast Metropolis in the year 2013. Out of the total number, 35,181 (representing 88%) were waterborne diseases with diarrhoeal diseases accounting for about 70% of reported cases. Even though the cause of the high incidence of waterborne diseases have not been entirely attributed to the operations of water-tanker services, the water delivered by the water-tanker services may be a contributory factor. A previous study conducted by Obeng et al. (2010) identified poor management of the hydrant and tankers by the GWCL and operators respectively as the cause of the poor quality of water delivered by water-tankers to customers. Based on their recommendations, GWCL paved the surroundings of the hydrant and provided structures for hanging the water hoses used by the tanker operators to draw water from the hydrant. What is yet to be confirmed is whether there has been improvement in the quality of water delivered by tanker operators to their customers.

This research is a follow-up to the research conducted by Obeng et al. (2010) and seeks to examine by laboratory analysis, samples of water supplied by water tanker operators in the

Cape Coast Metropolis to ascertain the quality of the water and its contribution to the health of water consumers in the Metropolis.

2. Materials and methods

The methodology used by Obeng et al. (2010) was adopted for this follow-up study.

2.1 Sampling Points

Samples of water for analysis were taken from a water hydrant located at the GWCL premises – Cape Coast, water tankers and a GWCL customer (a public standpipe located at Ankaful Village). The samples from the water hydrant and GWCL customer were analyzed to check the quality of the source water. Deterioration in quality of the source water would be attributed to GWCL and would impact on the quality of water in the tankers. Water samples from the water tankers were used to investigate any changes in quality which could be attributed to contamination from the tankers or the source water.

2.2 Sample Size

Ten (10) water samples from five (5) water tankers, one (1) each from the GWCL customer and the water hydrant were each sampled in the months of January and March. The five (5) water tankers were randomly selected on the basis of their regularity in drawing water from the water hydrant. The GWCL customer (a public standpipe located at Ankaful Village) was selected based on the population that the stand pipe serves.

2.3 Sampling procedure and precautions

Materials (sample bottles, medium containing agar) used in the research were sterilized by autoclaving at 121^{o}C for 15 minutes. Sodium thiosulphate solution of 100 g/l was added to 1.5 litre plastic bottles used for sampling before autoclaving. The use of the sodium thiosulphate was to stop the fungal effect of residual chlorine from acting on any fungi that may be present in the water sample (Okpako et al., 2009). During collection, taps were disinfected and flushed several times and allowed to run for 5 minutes to remove any contamination from the taps that may affect the quality of the water samples. Glassware and sampling bottles to be used were thoroughly washed with detergent and properly rinsed with tap water followed by distilled water. Sample bottles were opened and water quickly collected making sure that the bottles did not touch the taps before, during and after collection to add any contamination to the samples.

For the physical examination, samples were collected in plastic jerry cans thoroughly washed with detergent and properly rinsed with tap water followed by distilled water. In the case of chemical tests, samples were collected in glass bottles of more than 2 litres capacity. For bacteriological analysis, taps as well as caps of culture tubes were flamed for about two minutes with ignited cotton wool soaked with methylated spirit so as to kill all bacteria around the taps and caps of culture tubes. This was done to ensure results obtained were a true reflection of the characteristics of the various water samples collected.

2.4 Sample Preservation

To minimize bio-degradation between sampling and analysis, samples were kept as cool as possible without freezing in ice or refrigeration system set on 4ºC. The samples were transported to the laboratory and analyzed within 72 hours of collection. For bacteriological tests, samples were analyzed within 48 hours after sampling.

2.5 Sample analysis

Water samples were analyzed for colour, Taste and Odour, turbidity, Total Iron, TDS, alkalinity, chloride, fluoride, nitrite, nitrate and bacteriological (E-coli). Taste and odour were analyzed by the human sense. Colour, Turbidity, Total iron, Fluoride, nitrite and nitrate analysis was performed using Hach DR/3000 spectrophotometer. Chloride and Alkalinity were analyzed by acid titration methods. The Multiple Tube Fermentation Method was used for the E-coli (bacteriological) analysis. All analysis were performed according to Standard Analytical Methods (APHA et al., 1998).

3. Results and discussion

The results from the physico-chemical and bacteriological characteristics of the samples are summarized and presented in Tables 1 and 2.
The means and standard deviations of all parameters are computed for the samples from the five water-tankers. For the remaining sampling points (the hydrant, and Ankaful Village Standpipe), the means of the two samples collected in January and March were also computed. These data and the WHO guidelines for each parameter considered are presented on Table 1 and Table 2.

Table 1: Summary of Results of Physico-chemical and bacteriology characteristics of samples from GWCL Hydrant and Customer for the Months of January and March

Parameter	Unit	Water Hydrant		GWCL Customer		WHO (2008) GV
		Range	Mean	Range	Mean	
Colour	mg/l Pt-Co	8 – 10	9	4 – 5	4.5	15
Taste	-	Unobjectionable				
Odour	-	Unobjectionable				
Alkalinity	mg/l	30 – 32	31	21 – 23	22	-
Turbidity	NTU	3.24 – 3.62	3.43	2.51 – 2.68	2.6	5*
TDS	mg/l	286 – 298	292	119 – 121	120	1200*
Total Iron	mg/l	0.19 – 0.21	0.20	0.18 – 0.20	0.19	0.3*
Chloride	mg/l	31 – 33	32	33 – 35	34	250*
Fluoride	mg/l	0.43 – 0.44	0.44	0.48 – 0.49	0.49	1.5
Nitrite	mg/l	0.05 – 0.06	0.06	0.05 – 0.06	0.05	3 (STE) 0.2(LTE)
Nitrate	mg/l	4.8 – 5.1	4.95	4.9 – 5.0	4.95	50
E-coli	MPN/100ml	0	0	0	0	0

* Not a health-based value, but an aesthetic, taste or practical guideline
STE – Short-term Exposure *LTE – Long-term Exposure*

3.1 Quality of Water at the Hydrant and that served to GWCL Customer

The results from the laboratory examination (**Table 1**) indicates that water sampled from the GWCL customer and the hydrant satisfied the WHO Guidelines in all the parameters considered. No E-coli values from the GWCL customer and hydrant suggest that there was no bacterial contamination within the GWCL network which supports the fact that the water supplied by the Company is of good quality.

3.2 Quality of Water in the Tankers

Table 2: Summary of Results of Physico-chemical and bacteriology characteristics of samples from Water Tankers for the Months of January and March

Parameter	**Unit**	**Water-tankers**		**WHO (2008) GV**
		Range	**Mean**	
Colour	mg/l Pt-Co	*16 – 23*	*19.19 ± 1.88*	15
Taste	-	Unobjectionable		
Odour	-	Unobjectionable		
Alkalinity	mg/l	30 – 36	32.31 ± 1.99	-
Turbidity	NTU	*5.21 – 15.3*	*8.05 ± 2.82*	5*
TDS	mg/l	642 – 943	774 ± 78.85	1200*
Total Iron	mg/l	*0.33 – 0.91*	*0.54 ± 0.21*	0.3*
Chloride	mg/l	32 – 45	35.25 ± 3.47	250*
Fluoride	mg/l	0.2 – 0.9	0.58 ± 0.20	1.5
Nitrite	mg/l	0.03 – 0.08	0.05 ± 0.015	3 (STE); 0.2(LTE)
Nitrate	mg/l	18 – 29	24.44 ± 3.39	50
E-coli	MPN/100ml	*>16*	*>16*	0

Parameters higher than the guideline value are presented in italics
* Not a health-based value, but an aesthetic, taste or practical guideline
STE – Short-term Exposure   *LTE – Long-term Exposure*

The physico-chemical and bacteriological examination (**Table 2**) revealed that all the water samples from the four water-tankers examined failed in colour, total iron, turbidity and bacteriological quality. Since water from the hydrant before entering into the tankers met the WHO guidelines, the high levels of iron could be attributed to the occurrence of rust in most of the water-tankers which may into the water increasing the iron content and making the water turbid and apparently increasing the colour of the water. Although the samples failed in total iron, no objectionable taste was recorded which is contrary to WHO (2008) stating that water with objectionable taste is mostly caused by high iron content. The low TDS value with unobjectionable taste confirms WHO (2008) assertion that taste is affected by TDS. According to the water tanker operators, there is no formal cleaning method and frequency adopted. After discharging water to customers, the excess water is flashed out of the tank. This is the only mode of cleaning and no disinfection is carried out.

The high levels of colour, turbidity, total iron and E-coli count could be due to poor management of the tankers (improper cleaning and lack of disinfection). The high turbidity levels (range value of 5.21 – 15.3 NTU and a mean value of 8.05 ± 2.82 NTU against a guideline value of 5 NTU) in the tankers may have resulted in the high levels of E-coli counts (>16 MPN/100ml against a guideline value of 0 MPN/100ml) recorded. Turbidity has been associated with higher levels of disease-causing micro-organisms such as bacteria (Schafer et al., 2009, Shittu et al., 2008). The high turbidity and colour levels of the water suggest demand of higher dosages of disinfectants (Hoko, 2008). The poor bacteriological quality of the tanker water supports the high incidence of diarrhoea recorded in the metropolis and confirms (WHO, 2003, Hutin et al., 2003, Zamberlan da Silva et al., 2008). In addition, the high colour, turbidity, total iron and E-coli count in the tankers could not have come from the hydrant since the quality of water at the hydrant passed in all parameters.

Furthermore, the failure of the water samples from the water-tankers to meet the WHO guidelines for colour and turbidity implies that the physical characteristics of the water is unacceptable and this could have raised the concerns by some patrons of the water-tanker services about the quality of water supplied by the water-tanker operators. The findings confirms the assertion by Magwood (2005) that colour and suspended matter are important water quality indicators by consumers and Okpako et al. (2009) description of potable water as being 'a transparent liquid without colour, taste or odour'. The mean values for colour (19.48±4.48 mg/l Pt-Co), turbidity (7.39±3.85 NTU), total iron (0.46±0.29 mg/l) recorded in a study conducted by (Obeng et al., 2010) on the quality of tanker water in Cape Coast were similar to those obtained in this study (19.19±1.88 mg/l Pt-Co for colour; 8.05±2.82 NTU for turbidity; 0.54±0.21 mg/l). However, the number of E – coli recorded in this study (>16 MPN/100ml) was significantly low than that reported by Obeng et al. (2010) (>23 MPN/100ml). The activities of water-taker operators are not monitored and so it is possible that the tankers may be used to transport untreated water.

4. Conclusion

The following conclusions are drawn from the analyses of the results.

1. Irregular cleaning and lack of disinfection of water-tankers accounts for the poor quality of water supplied by the water-tanker operators.
2. The water treated and distributed by GWCL is of good quality and does not pose any health risk to its consumers and therefore cannot be attributed to the poor quality of water supplied by the water-tanker operators.
3. The poor quality of water supplied by the water-tanker operators could be attributed to the high incidence of water-related diseases notably diarrhoea recorded in the metropolis.

5. References

1. Apha, Awwa & Wef, (1998), Standard Methods for the Examination of Water and Wastewater, Washington DC, American Public Health Association, American Water Work Association, Water Environment Federation.

2. Craun, G.F., (1991), Causes of waterborne outbreaks in the United States. Water Science & Technology, 24, pp 17-20.

3. Elimelech, M, (2006), The global challenge for adequate and safe water. Journal of Water Supply, Research and Technology. AQUA, 55, pp 3-10.

4. Hoko, Z, (2008), An assessment of quality of water from boreholes in Bindura District, Zimbabwe. Physics and Chemistry of the Earth, 33, pp 824-828.

5. Howard, G. & Bartram, J, (2003), Domestic water quantity, service level, and health, Geneva, World Health Organization.

6. Hutin, Y., Luby, S. & Paquet, C, (2003), A large cholera outbreak in Kano City, Nigeria: the importance of hand washing with soap and the danger of street-vended water. Journal of Water Health, 1, pp 45-52.

7. Magwood, S, (2005), Drinking water quality and well owner perceptions of quality in a rural watershed in British Columbia, Canada. Proceedings of the 2005 Puget Sound Georgia Basin Research Conference, March 29-31, 2005, Washington State Convention and Trade Center in downtown Seattle.

8. Mcgranahan, G. & Owen, D. L, (2006), Local water companies and the urban poor, IIED, Human Settlements Discussion Paper Series, Theme: water-4.

9. Mehta, M., Virgee, K. & Njoroge, S. (2007), Helping a New Breed of Private Water Operators Access Infrastructure finance: Microfinance for Community Water Schemes in Kenya. Washington D.C: Public-Private Infrastructure Advisory Facility (PPIAF).

10. Nath, K. J., Bloomfield, S. F. & Jones, M, (2006), Household water storage, handling and point-of-use treatment. International Scientific Forum on Home Hygiene (IFH).

11. Obeng, P. A., Dwamena-Boateng, P. & Ntiamoah-Asare, D.J, (2010), Alternative drinking water supply in low-income urban settlements using tankers: A quality assessment in Cape Coast, Ghana. Management of Environmental Quality: An International Journal, 21, pp 494-504.

12. Okpako, E. C., Osuagwu, A.N., Duke, A. E. & Ntui, V. O, (2009), Prevalence and significance of fungi in sachet and borehole drinking water in Calabar, Nigeria. African Journal of Microbiology Research, 3, pp 56-61.

13. Schafer, A. I., Rossiter, H. M. A., Owusu, P. A., Richards, B. S. & Awuah, E, (2009), Physico-chemical water quality in Ghana: Prospects for water supply technology implementation. Desalination, 248, pp 193-203.

14. Shittu, O. B., Olaitan, J. O. & Amusa, T.S, (2008), Physico-chemical and bacteriological analyses of water used for drinking and swimming purposes in abeokuta, nigeria. African Journal of Biomedical Research, 11, pp 285-290.

15. UNEP, (1992), Agenda 21 - Sustainable Development, Switzerland, United Nations.

16. WHO, (2003), Assessing Microbial Safety of Drinking Water Improving Approaches and Methods: Improving Approaches and Methods, OECD Publishing.

17. WHO, (2008), Guidelines for drinking-water quality [Electronic Version]: Third edition incorporating first and second addendum. Volume 1, Recommendations, Geneva, World Health Organization.

18. WHO & UNICEF, (2006), Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade. Geneva:

19. WHO. Zamberlan DA Silva, M. E., Santana, R. G., Guilhermetti, M., Filho, I. C., Endo, E. H., Ueda-Nakamura, T., Nakamura, C. V. & Dias Filho, B.P, (2008), Comparison of the bacteriological quality of tap water and bottled mineral water, International Journal of Hygiene and Environmental Health, 211, pp 504-9.