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Physicochemical Quality of Water Produced at Kwanyaku Water Treatment Plant in the Agona District of the Central Region of Ghana

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ABSTRACT

It is very essential and important to test water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested for different physico-chemical parameters. Selection of parameters for testing of water quality solely depends on the purpose for which the water is to be used and the extent of its quality and purity needed. Some physical tests should be performed for testing of its physical appearance such as temperature, colour, odour, pH, turbidity and conductivity while chemical tests should be performed for its alkalinity, hardness and residual chlorine. The study was conducted to assess the physicochemical quality of water produced at the Kwanyako Water Treatment Plant in the Central Region of Ghana. Triplicate water samples were collected in sterile 500ml polypropylene bottles, from Raw, Settled, Filtered and Final water and examined for the physico-chemical parameters mentioned above, using the World Health Organsation (WHO) approved methods of analysis. The study was carried out for a period of 6 months (September, 2013 to February 2014). The values recorded for all the physico-chemical parameters were within the WHO acceptable limit except for the colour and turbidity of the Raw water. This implied that, the water produced at the Treatment plant is efficiently treated with regards to the physicochemical parameters.

Introduction

Access to safe water is not just an issue for developing countries (Supply, & UNICEF, 2000). Despite wealthy economies and their access to proven drinking water-treatment technologies significant outbreaks of waterborne intestinal diseases have occurred in North America and Western Europe in the past Dufour & Bartram, 2012; Mansour-Rezaei, & Naser, 2013). For this reason, the World Health Organisation (WHO) has given a guideline for all drinking water irrespective of location. The WHO guidelines for drinking water are that it should be free from pathogenic organisms, low in concentration of compounds that are acutely toxic or that have serious long-term effects such as lead, clear, not saline, free from compounds that cause offensive odour or taste, and non-corrosive nor should it cause encrustation of piping or staining of clothes (WHO, 2004; Abhineet, & Dohare, 2014; Engdaw, 2014).

The presence of odour, colour and particles in drinking water may result from source water contamination by human and animal activities. These physical indicators suggest the extent of pollution. Contamination by sewage or human excrement from septic tanks, open dumps, improper constriction latrines and surface impoundments are the most common sources for water contamination and presents the greatest danger to public health (Dufour & Bartram, 2012; Aidoo, 2013; Mansour-Rezaei, & Naser, 2013). Thus, regular examination of water must be conducted to ensure its' safety. The United States Environmental Protection Agency regulations (USEPA, 1999) and WHO guidelines for water treatment require that the water be analysed for physicochemical qualities such as pH, colour, turbidity, total hardness, temperature, alkalinity and chlorine residual (WHO, 2011) These parameters have a correlation with the presence of pathogens in the source water and growth of microorganisms in the distribution system (Abhineet, & Dohare, 2014; Engdaw, 2014).

Temperature is one factor that always correlates with microbial growth rates. Temperature is considered as a critical parameter since it has 17 significant impact on many reactions, including the rate of disinfectant decay and by-product formation (Volk et al., 2002). Increasing temperature influences microbial growth directly and indirectly; directly by increasing microbial metabolism, and indirectly by dissipating disinfectant residuals and increasing corrosion rates.

pH is used in determining the corrosive nature of water, and one of the most important operational parameters for water treatment in relation to disinfection, coagulation/flocculation and pH adjustment. Dissociation is poor at pH levels below 6.0, from pH 6.0 to 8.5 a nearly complete dissociation of Hypochlorous acid (HOCl) occurs. Thus, for disinfection with chlorine control of pH is critical.

Turbidity in drinking water is caused by particulate matter that may be present from source water as a consequence of inadequate filtration or from re-suspension of sediment in distribution system (WHO, 2004). Low turbidity levels are required to minimize risk of exposure to disease-causing organisms in drinking water. All the other parameters

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including colour, hardness, alkalinity and chlorine residual are also very good indicators of water pollution and therefore are of concerns to public health (Olson, 2003).

Problem Statement

The principal aim of every conventional drinking water treatment plant should be to provide acceptable standards of service, to gain customer satisfaction, delivering water that is both aesthetically pleasing to consumers and meeting public health safety requirements (Chowdhury, 2003). In developing countries 2.2 million people, most of them children, die every year from diseases associated with lack of safe drinking water, inadequate sanitation and poor hygiene. Diarrhoeal illness remains a major killer in children and it is estimated that 80% of all illnesses in developing countries are related to water and sanitation (Supply, & UNICEF, 2000). For this reason, both drinking water standards and technology, in recent years, have changed to help ensure safe drinking water for public consumption. As water treatment standards have become more stringent, the methods of analysis have become more sophisticated, drinking water utilities may have to consider changing disinfectants to improve water quality and meet more stringent disinfection regulations (Volk *et al*., 2002).

Over the years the Ghanaian populace has raised a lot of concern about the quality of water produced and supplied by the Ghana Water Company Limited (GWCL). This study was to determine the physicochemical quality of the water produced by the Kwanyako Water Treatment Plant.

Methodology

The study used the experimental research design to determine the Physical and Chemical qualities of the water sampled. Pre-analytical activities included collection of all glassware and other materials and Sterilisation.

Triplicate water samples were collected from Raw, Settled, Filtered and Final water. The water samples were examined for the selected physico-chemical parameters using appropriate instruments and methods of analysis. The method of sample collection at each source was according to the WHO Guidelines (WHO, 2011) for drinking water quality assessment. The water samples collected in the entire sampling period were analyzed for pH, Turbidity, Colour Temperature, Conductivity, Residual chlorine Alkalinity and Total Hardness. The One Way Analysis of Variance (ANOVA) was adopted for the analysis. The means, sum of squares, mean square, F ratio and the probabilities were calculated at the 95% confidence level using the Statistical Package for the Social Sciences (SPSS).

The methods are detailed below

The pH was measured using the Lovibond 2000 pH comparator. This was done by introducing 10 drops of bromothymol blue into the comparator tube filled with 10 ml sample. The mixture was swirled to ensure a thorough mixing and then placed in the right hand compartment. The colour produced in the test tube was compared to the colours on the standard disc by rotating the disc until a colour match was obtained and recorded. Turbidity measurements were made using a HACH DR 2000 spectrometer. 10 ml of each sample was poured into the tube and placed in the apparatus for the reading to be recorded. Colour was measured using the B.D.H Lovibond Nessleriser. The comparator has two compartments and two tubes. One tube contains distilled water to serve as a control. Into the other tube, 50 ml of each sample was poured and compared to the control by rotating the disc to read the colour number that matched directly with the control. This was done in turns and the colour recorded. The temperature of each water sample was determined by introducing a Celsius scale thermometer into about 200 ml of each sample in a beaker and the temperature recorded. Conductivity measurements were made using HACH HQ40d conductivity meter. 100 ml of each sample was poured into a beaker and the electrode placed in it. The measurement was read directly in micro Siemens per centimeter (µS/cm). Free chlorine residual, for each chlorinated sample was determined at site of collection with a Lovibond 2000 Comparator system, using a DPD No.1 chlorine tablet. One tablet was dissolved in 10 ml of each sample, placed in the comparator and compared to record the figure that matched the colour obtained when the tablet was dissolved after five minutes. In determining the alkalinity, three drops of methyl orange indicator were added to 100 ml of each sample and titrated against 0.2 mol/dm3 HCl. The average titre was multiplied by 10 to determine the amount of CaCO3 in one litre of sample. For total hardness 50 ml of sample was taken and one to two drops of buffer solution was prepared by mixing 1.179 g Na2EDTA.2H2O and 780 mg MgSO4.7H2O in 50 ml plus 16.9 g of Ammonium Chloride (NH4Cl) in 143 ml concentration of Ammonium Hydroxide (NH4OH) and diluted to 250 ml to produce a pH of 10. 2. 43 Two drops of Eriochrome black T indicator was added and titrated slowly with EDTA until the end point where the colour changed from pink to blue

Findings and Discussion

pH

The microbial activity of chlorine is greatly reduced at high pH, the lower the pH value the higher is the corrosive nature of water (Herrmann *et al.*, 2003). pH values ranging from 3 to 10.5 could favour both indicator and pathogenic microorganism growth (Wang, Yuan, & Pei, 2014)). The pH values of the Raw and Final water at the treatment station fell within the WHO guideline values (Figure. 1) while those for Settled and Filtered water had their values for the months of October and November, 2013 and February, 2014 below acceptable WHO limits (6.5-8.5). These pH values indicated slightly acidic nature of the water. The analysis of variance (ANOVA) results for the Raw and Final water (p=0.29) showed that there is no significant difference between the average values implying that the average values are not statistically significant. This further indicated that the effective measures were effected during the water treatment stage that maintained the acceptable ph for the final water to ensure the prevention of all health related issues.

Turbidity

Except for the Raw water which recorded high Turbidity values above the WHO guideline values of ≤ 5 NTU. Settled, Filtered and Final water had values within the acceptable limit (Figure 2). The Turbidity values decreased from the Raw to the Filtered water then slightly increased from the Filtered to the Final water. High Turbidity values were recorded in October and December, 2013. Since turbidity is a vital microbiological parameter (Breach 2011; Engdaw, 2014). The values recorded guided the amount of chemicals to be added to rid the water off pollutants. The ANOVA results (0.00) showed that there was significant difference in the true average values of the Raw and Final water. This also implied that despite the high turbidity values recorded in some months of the year, the water treatment was efficient in achieving an acceptable turbidity measure.

Residual Chlorine

Maintaining an adequate level of residual chlorine is of great importance in terms of distribution water quality management (Breach, 2011). A contamination causing a disease outbreak in a distribution system may be prevented by a chlorine demand sufficient to destroy entirely the pathogenic organisms Mansour-Rezaei, & Naser, 2013). Residual Chlorine was only measured for the Final water. All the values recorded were within the acceptable limit of WHO guideline of 0.6-1.00 mg/l except for the month of November which recorded a value of 1.7 mg/l (Figure 3). This implied that any microorganism that gets into the distribution system will be destroyed by the residual chlorine in the final water.

Colour

The colour of the Raw water may be from the amount of humic acid resulting from organic soils such as peat and decayed vegetation (Breach, 2011). Water colour is an important indicator of the water pollutants and microbial activity (WHO, 2011). Raw water values for colour were way above the WHO guideline whilst Settled, Filtered and Final water values met the WHO standard of less or equal to 15 HU (Figure.4). The colour of the water greatly improved at the Settled water point and further with the Filtered and Final water. Very high colour values were recorded in October, November and December, 2013 for the Raw water. The ANOVA results for the Raw and Final water (0.00) showed that the difference colour values were statistically significant.

Temperature

The Temperature values for all the sample types were above the acceptable limit of the WHO guideline value of 25^0C. The Temperature values for the Final water were higher than those of all the other sample types for the entire sampling period (Figure 5). The temperature indicator will be a guide to the amount of chlorine to be added to maintain a good level of residual chlorine in the distributed water (Volk et al., 2002). The ANOVA results for the Raw and Final water (0.02) showed that the difference in temperature values were statistically significant.

Conductivity

Electrical Conductivity is a good indicator of total salinity of and has a significant correlation with temperature, pH, Hardness Alkalinity and Chloride levels. Kumar and Sinha (2010), suggest that drinking water quality of a study area can be checked effectively by controlling conductivity of the water. The Conductivity values for all the sample types were within the acceptable limit of the WHO guideline value of < 300 µS/cm. There was however no clear pattern in the conductivity values over the sampling period as shown in the Figure 6. The ANOVA results for the Raw and Final water (0.4) showed that the difference in conductivity values were not statistically significant.

Alkalinity

Alkalinity is significant in treatment of drinking water because it influences processes such as anaerobic digestion due to the carbonate content thus low and High pH both affect microbial growth in water (Kumar, & Sinha, 2010; Sengupta, 2013).Alkalinity values for Raw water for the entire sampling period were higher than those for the Settled, Filtered and Final water. In all cases the Alkalinity values decreased in the Settled and Filtered water but increased in the Final water (Figure 7.) All the values recorded were within acceptable limit of WHO guideline, which is < 200 mg/l. The ANOVA results for the Raw and Final water (0.12) indicated that there was no significant difference between the true average values, hence the average values are not statistically significant.

Total Hardness

Hardness of water is caused principally by the elements Calcium and Magnesium. Hardness levels above 200mg/l may cause scale deposition in water distribution system and may also cause laxative effects (Sengupta, 2013).

All the Total Hardness values recorded for Raw, Settled, Filtered and Final water were within the acceptable range of the WHO guideline of 0 – 200 mg/l. The Total Hardness figures recorded for the Final water for the entire period were above those for Raw, Settled and Filtered water. The values were also almost stable for Raw, Settled and Filtered water (Figure 8). The ANOVA results (0.07) showed that there was no significant difference in Total Hardness average values of the Raw and Final water.

Conclusion

The Results obtained from the physico-chemical analyses of the Final water produced at the Kwanyaku Water Treatment Plant revealed that all the parameters were within the WHO guideline values. The quality of water produced by the GWCL at the Kwanyaku Water Treatment Plant with regards to the physico-chemical properties is within the acceptable limit of WHO and poses no health threat to consumers. However, the study should be extended to determine the bacteriological at the treatment plant, both the physico-chemical and bacteriological quality of treated water at consumer point and the study should be replicated at all other treatment plants in the country.

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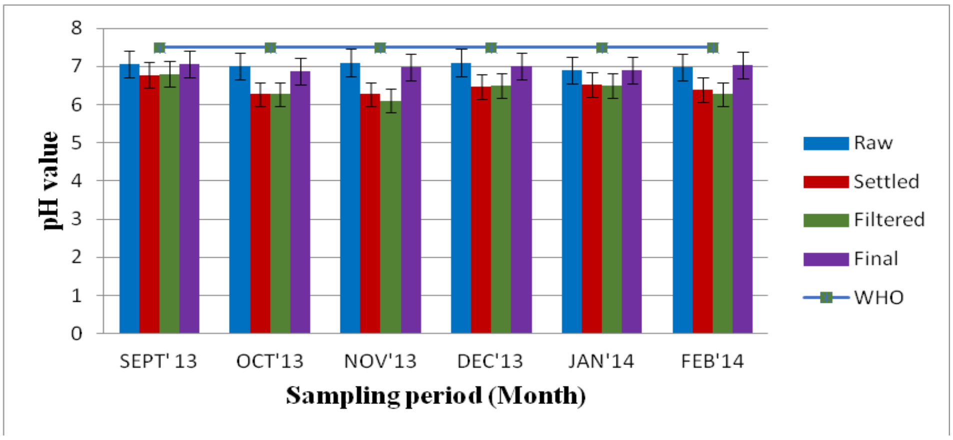

Figure. 1. pH values of water at the treatment station from September, 2013 to February, 2014.

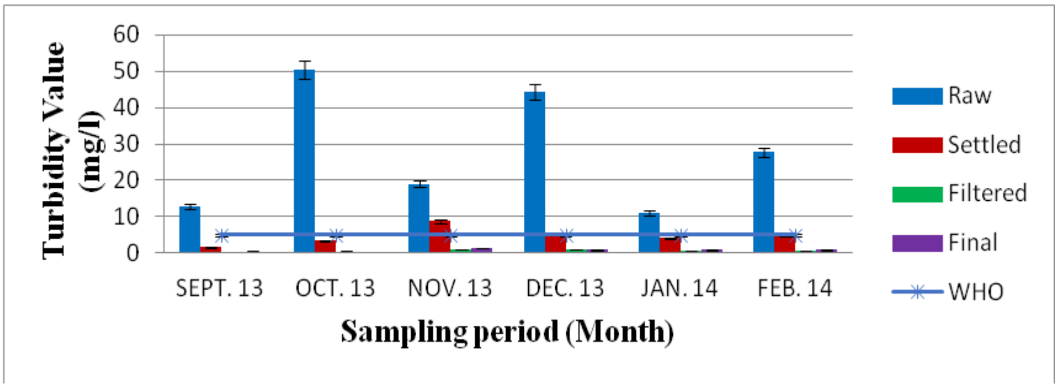

Figure. 2. Turbidity of water at the treatment station from September, 2013 to February, 2014.

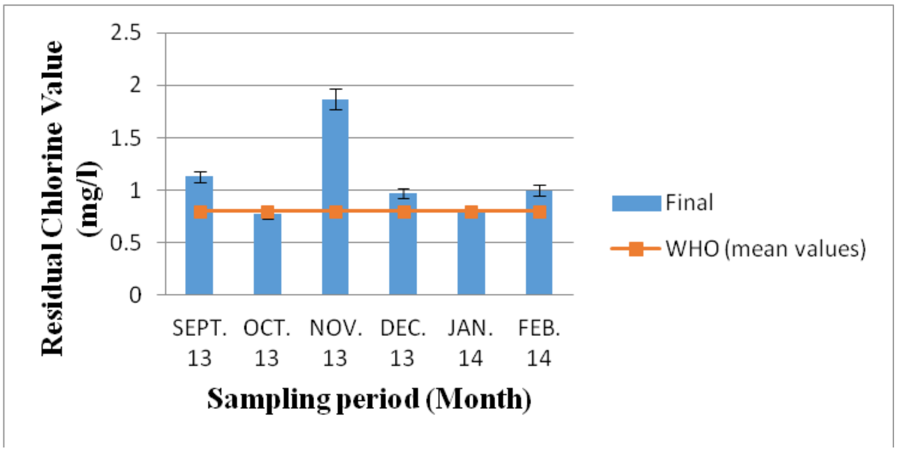

Figure. 3. Residual Chlorine of water at the treatment station from September, 2013 to February, 2014.

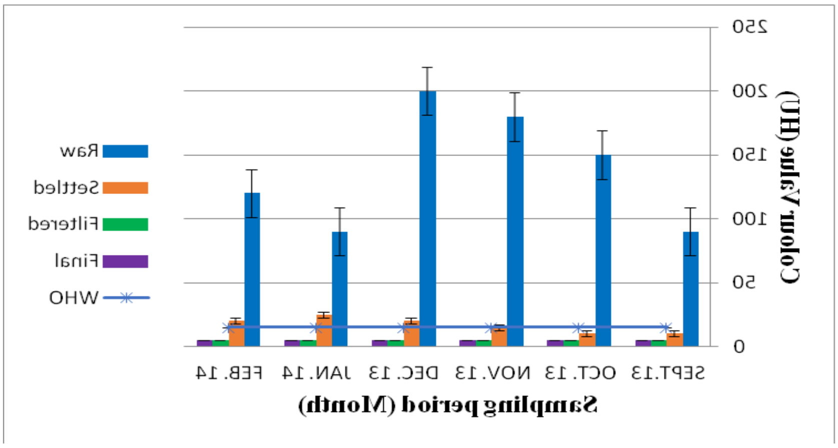

Figure. 4. Colour of water at the treatment station from September, 2013 to February, 2014.

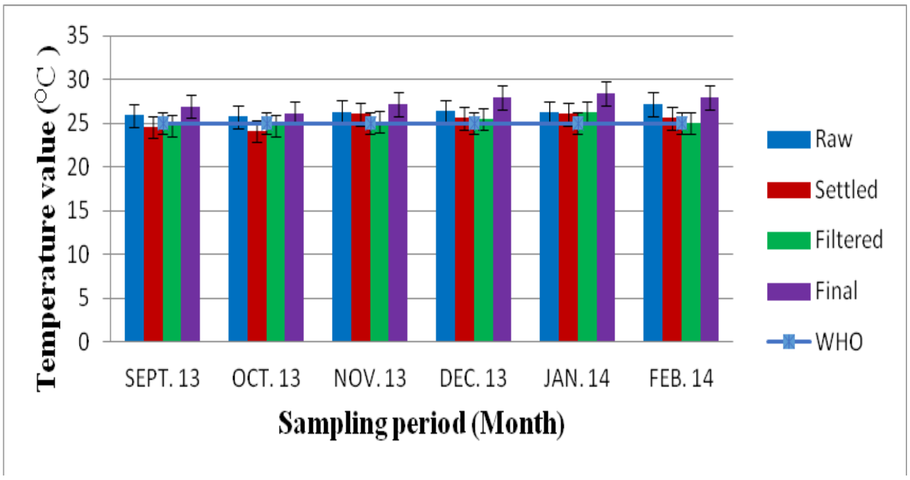

Figure. 5. Temperature of water at the treatment station from September, 2013 to February, 2014.

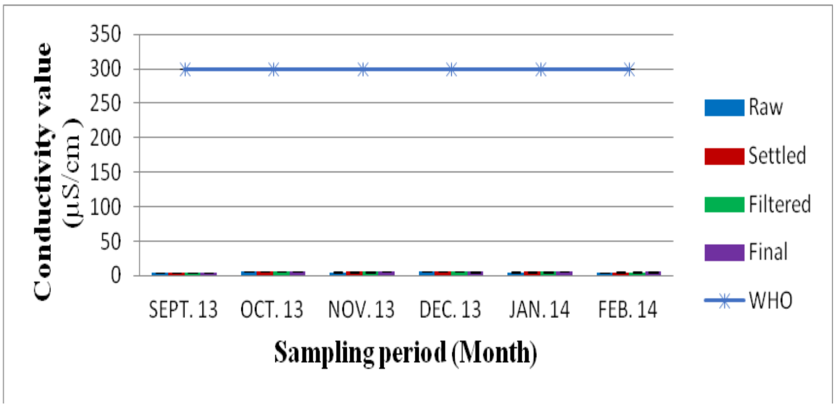

Figure. 6. Conductivity of water at the treatment station from September, 2013 to February, 2014.

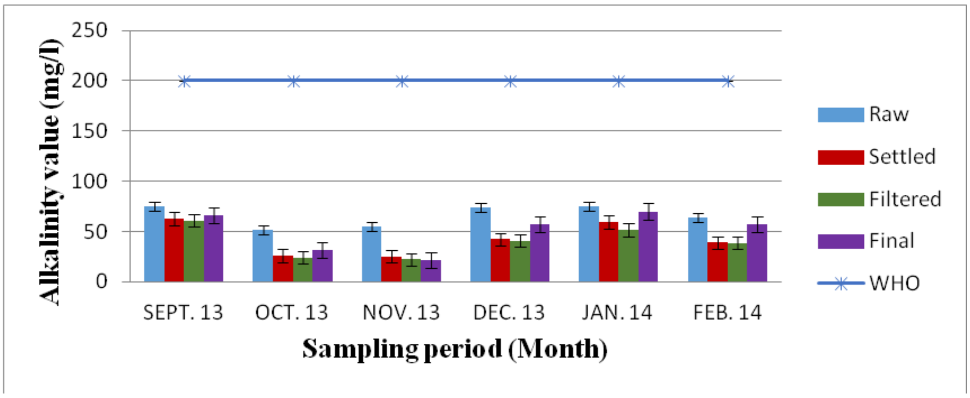

Figure. 7. Alkalinity of water at the treatment station from September, 2013 to February, 2014.

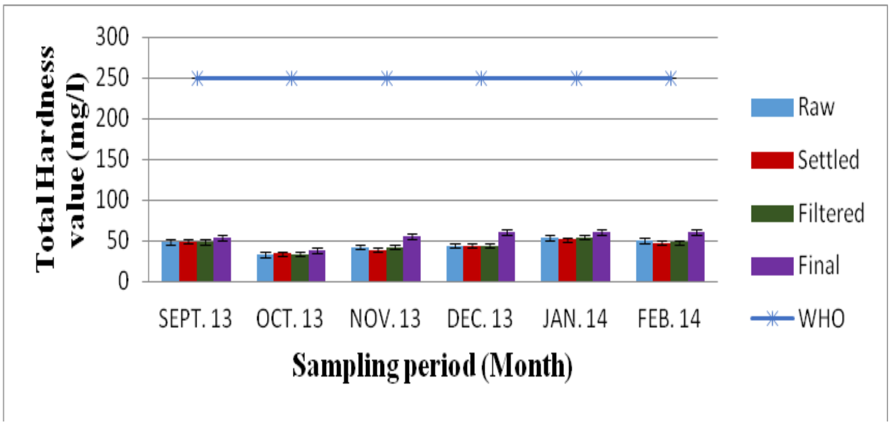

Figure. 8. Total Hardness of water at the treatment station from September, 2013 to February, 2014.

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