Assessment of Regulated Disinfection By-Products in Ahmadu Bello University Community Drinking Water Supply

E. M. Shiabu-Imodagbe, C. A. Okuofu, J. P. Unyimadu and W. Akan

Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria
Department of Physical Chemistry, Institute of Oceanography and Marine Research, Victoria Island, Lagos
Department of Chemistry, Covenant University, Otta, Ogun State

The Drinking water produced from the Ahmadu Bello University (ABU) water treatment plant was assessed for its quality in terms of its regulated disinfection by-products (DBPs) content between 2008 and 2010. There were highly significant differences in mean concentration levels of these DBPs in the stages of treatment and distribution of the drinking water (F=4.86** - THMs, F=4.93** - HAAs). The pattern of variation of the Trihalomethanes was varied among the regulated trihalomethanes (THMs) while that of the haloacetic acids was consistent, decreasing from after chlorination stage to house level. Only THMs are regulated under the Nigerian drinking water standard with a maximum contaminant level of 0.001 mg/l as against international limits of 0.080 mg/l (USEPA) and 0.10 mg/l (WHO, EU). Mean concentration levels at booster station storage tanks were 0.0013 mg/l (THMs) and 0.5934 mg/l (HAAs) while at house level mean levels were 0.0107 mg/l (THMs) and 0.4863 mg/l (HAAs). These values show that drinking water produced by the ABU water treatment plant is non-compliant with national standard, but is readily compliant with international standards - USEPA, WHO and EU. However in terms of haloacetic acids (HAAs) the treated water had higher than the maximum permissible limits for HAAs under any of the standards. This calls for more concerted effort in monitoring for these DBPs and reducing their levels in the treated water.

Introduction

Clean, healthy and secure drinking water is a fundamental human right. So declared the United Nations Committee on Economic, Cultural and Social Rights and adopted by the General Assembly of The United Nations in December, 2002. This is because water is indispensable for leading a healthy life in human dignity. It is also a prerequisite to the realisation of all other human rights and as such this right has been so infused (ENS, 2002). Associated with this, is the fact that drinking water is a fundamental requirement of the human body that cannot be replaced. Indeed water is vital to all living resources, plants and animals alike as well as an indispensable economic resource that plays a fundamental role in climate change (WISE, 2011).

The Ahmadu Bello University, Zaria, Nigeria is one of the foremost universities in Nigeria. It was established in 1962 as two campuses situated in a land area of about 7,000 hectares north and south of Zaria metropolis. The main campus which is the larger of these campuses is about three quarters of this total land area (ABU, 2012). The Ahmadu Bello University (ABU) drinking water treatment plant is in the main campus supplying drinking water to students, staff, their dependant families and some people from Samaru village.

The ABU water treatment plant was commissioned in 1981 when the Zaria municipal water supply was found to be incapable of meeting the drinking water needs of the Ahmadu Bello University community. This plant is a conventional single train, one disinfection stage water treatment plant. Raw water from the River Kubanni is impounded into a manmade reservoir to provide the stored water for the treatment plant. The water treatment plant is located within the university premises at an elevation of 655 meter MSL on latitude 11°08'25.60"N and longitude 7°39'19.65"E. Raw water is abstracted by two low lift pumps and treated in five sand gravel filters, three bottom hopper type sedimentation tanks, one liming unit and one disinfecting unit to presently produce 4.8 million litres/day. It also has a clear water well of 1.500 m3 capacity, with three high lift pumps. Part of the treated water is sent to the booster station which has two tanks - concrete capacity (110m3) and steel tank (capacity 117m3) for storage and distribution to houses on higher elevations. The other part is sent to the elevated tank near the University Senate building to supply most academic areas, students' hostel and some residential houses. At the moment, water is distributed intermittently to areas on high elevations from the booster station (Amen, 2004). It is part of the study to identify how far the treatment plant provides safe drinking water to the academic community by determining the levels of Disinfection-by-Products (DBPs) that are regulated under national and international standards in the finished drinking water.

Disinfection By-Products (DBPs) are produced when the disinfectant in use during water treatment combines with dissolved organic matter or its intermediate product such as humus, fulvic acids, and aldehydes in water. Among these DBPs are Trihalomethanes (THMs), Haloacetic acids (HAAs), Acetonitriles, Halo-keetones and volatile organic compounds (VOCs) (Stevens et al. 1989; USEPA 1990a, 1990b, 1991). Since 1989, over 500 of these DBPs have been discovered with many being discovered by the day. At the moment, there are many drinking water quality regulations. Among these are the American Safe Drinking Water Act (SDWA) of 1974 as modified up to 2001 (Amendment 66), 1980 EU Approved Drinking Water Directive (effective 1985) with its Integrated Disinfection Design Framework (IDD) and the Nigerian Drinking Water Standards. These regulations identified DBPs as having carcinogenic and mutagenic effects and are therefore likely to be injurious to health (Cox, 1997; Hydes, 1999; Stevens et al. 1989; USEPA 1990a, 1990b, 2001, 2011a, 2011b; Lipscomb, 2000). Among these legislations, the American SDWA has also been wide ranging documentation on these DBPs in drinking water. To date, only eleven of the known DBPs are statutorily regulated under the American SDWA as amended up to 2005 (Stevens et al., 1989; Owens, 2001). These regulated DBPs are four Trihalomethanes (THMs)-Trichloromethane (Chloroform), Bromodichloromethane, Tribromomethane (Bromoform), Dibromochloromethane; five Haloacetic Acids (HAAs)-Monochloroacetic Acid, Dichloroacetic acid, Trichloroacetic acid, Monobromoacetic acid, Dibromoacetic acid; Bromate and Chlorite. This study is limited to the regulated THMs and HAAs only in the drinking water produced by the treatment plant excluding bromate and chloride since the treatment plant uses only chlorine from calcium hypochlorite as disinfectant instead of ozone or chlorine dioxide.

Materials and Method

a) Sampling

Two Hundred and fifty two samples were taken in duplicates longitudinally along the treatment and distribution system of the ABU water treatment works from the source water (Kubanni reservoir) to an elevated Household (in Area E Quarters). These samples were taken between 2008 and 2010.

Simultaneously, samples were taken of the raw water, water after sedimentation, water after chlorination and water at the booster station. House level sample was taken from Area E House Number 20. Samples for Trihalomethanes and Haloacetic acids were taken in 60 ml glass vials with quantities of de-chlorinating agent (ammonium chloride) and stored at temperature about -4° C or less in ice filled jugs in accordance with USEPA method 551.1 (USEPA, 1995). In Analytical Method

Analyses of the water samples for the regulated disinfection by-products were in accordance with standard methods outlined in USEPA (1995) method 551.1 using Agilent Gas Chromatography calibrated with commercial standards supplied by Ultra Scientific Analytical Solutions, North Kingstown, USA. The results were later compared with national and international standards.
Table 2: Mean Levels of Regulated Haloacetic Acids (HAAs) as determined in Drinking Water from Ahmadu Bello University (ABU) Water Treatment Plant

<table>
<thead>
<tr>
<th>Type of HAA</th>
<th>Raw Water</th>
<th>After Sedimentation</th>
<th>After Chlorination</th>
<th>Booster Station Water</th>
<th>Household Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dibromoacetic acid</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.0027</td>
<td>0.0038</td>
<td></td>
</tr>
<tr>
<td>Trichloroacetic acid</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.0067</td>
<td>0.0078</td>
<td>0.0040</td>
</tr>
<tr>
<td>Methyl chloride</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.0026</td>
<td>0.0029</td>
<td></td>
</tr>
<tr>
<td>Total THMAs</td>
<td>BI BI</td>
<td>0.0067</td>
<td>0.00131</td>
<td>0.0017</td>
<td></td>
</tr>
</tbody>
</table>

BD – BELOW DETECTION

From Table 1 above, mean chloriform values were found to vary between below detectable limits for the raw water to the 0.0038 mg/l at household level. The below detection level for the raw water and of water after sedimentation is not surprising as disinfection is not undertaken at these stages of drinking water treatment. However the level after disinfection may be related to dissolved reaction between the disinfectant and the dissolved organic matter or its fractions as DBP precursors until in storage. In this study, the WHO guideline for HAAs is 0.002 mg/l. In this study, the chlorination level decreased to 0.004 mg/l at household level.

Conclusion

From the assessment, the drinking water produced by ABU water works had mean concentration levels of regulated THMs which were considerably lower than those of regulated HAAs. By these THMs concentration the treated water did not meet the prevailing Nigerian drinking water standard even though it meets international (USEPA, EU and WHO) standards. This can be attributed to the background of partial functioning service laboratories in many of Nigeria’s water treatment industry, the criteria for determining the national THM standard could be contested to lack objectivity and enforcement. The drinking water produced from the ABU water treatment plant can be considered as being potentially capable of causing increased risk of cancer traceable to its HAAs content. It is therefore necessary that all levels in the drinking water need further and constant monitoring with concerted effort to minimize their occurrence. It is by so doing that wholesome and potable delivery will be ensured to the university community.

References


Clark, R. M. and Thomas, R. C., 2001. Control of Microbes and DBPs in Drinking Water: An Overview. Controlling Disinfection By-Products and Microbial Contamination in Drinking water service laboratories in many of Nigeria's water treatment industry, the criteria for determining the national THM standard could be contested to lack objectivity and enforcement. The drinking water produced from the ABU water treatment plant can be considered as being potentially capable of causing increased risk of cancer traceable to its HAAs content. It is therefore necessary that all levels in the drinking water need further and constant monitoring with concerted effort to minimize their occurrence. It is by so doing that wholesome and potable delivery will be ensured to the university community.

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<th>Household Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichloroacetic acid</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.0335</td>
<td>0.0033</td>
<td>0.0012</td>
</tr>
<tr>
<td>Trichloroacetic acid</td>
<td>BI BI</td>
<td>BI BI</td>
<td>1.0758</td>
<td>0.3835</td>
<td>0.3456</td>
</tr>
<tr>
<td>Monochloroacetic acid</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.1285</td>
<td>0.1251</td>
<td>0.0971</td>
</tr>
<tr>
<td>Methyl chloride</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.0065</td>
<td>0.0052</td>
<td>0.0015</td>
</tr>
<tr>
<td>Dibromochloromethane</td>
<td>BI BI</td>
<td>BI BI</td>
<td>0.2148</td>
<td>0.0728</td>
<td>0.0409</td>
</tr>
<tr>
<td>Total Haloacetic acid</td>
<td>BI BI</td>
<td>1.8322</td>
<td>0.5334</td>
<td>0.4683</td>
<td></td>
</tr>
</tbody>
</table>

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