

# Occurrence and Levels of Acetonitriles as Emerging Disinfection By-Products in a Community Drinking Water Supply.

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## ABSTRACT

Drinking water from Ahmadu Bello University (ABU) Zaria water treatment plant was sampled and analysed for haloacetonitriles (HANs) disinfection by-products (DBPs) between 2008 and 2010. This was to determine the degree of wholesomeness of the drinking water supplied to the university community. On analyses, samples were found to positively contain dichloroacetonitriles, dibromoacetonitrile, and bromochloroacetonitrile among the commonly known haloacetonitriles in drinking water. They were detected at chlorination stage and sometimes in the house level water samples.

Bromochloroacetonitrile mean concentration of  $1.3927\text{E}-02 \pm 6.1033\text{E}-06$  mg/L was detected in the chlorinated samples and was lost in samples from the distribution system most probably due to its hydrolysis in water. On the other hand, mean levels of dibromoacetonitrile and dichloroacetonitrile were observed to increase from  $1.0605\text{E}-02 \pm 3.3349\text{E}-05$  mg/L of and  $1.36431\text{E}-03 \pm 1.4647\text{E}-06$  mg/L, respectively, in the chlorinated sample to  $2.4731\text{E}-02 \pm 5.2273\text{E}-04$  mg/L and  $2.2190\text{E}-03 \pm 1.8910\text{E}-06$  mg/L in the house level water samples, respectively. This trend in mean concentration could be traceable to influence of increased acidity (decreased pH) and total organic carbon. These showed that the treated drinking water supplied to the university community was within the WHO, 2004 provisional guideline recommendations that individual haloacetonitrile could have concentration exceeding 0.01 mg/L. However, the distributed water contained higher levels than the generally

assumed concentration of 0.002 mg/l (WHO, 2004). This has implication for increased glutathione (GSH) lipid peroxidation and covalent bond associated with haloacetonitrile related radioactivity to gut tissues resulting from scavenging reactive oxygen (ROS). Although not among the regulated DBPs, HANs presence in distributed drinking water could open up a new frontier of DBPs health risks. Hence, their levels need be monitored, their effects determined and adequately documented for regulation. Thus, would wholesome and potable drinking water (a human right) be guaranteed to the students, staff and their dependant family members of the ABU community.

(Keywords: *acetonitriles, Ahmadu Bello University, ABU, community water supply, potable water, drinking water*)

## INTRODUCTION

Water is an indispensable body requirement which cannot be replaced. It nourishes and sustains the body to keep it healthy and growing. The Ahmadu Bello University (ABU) community is predominantly an academic community where the value of wholesome and potable water is highly appreciated. It is in this regards that the management of the university established the ABU water treatment plant (ABU water works) in 1982 to supply potable water to the students, staff and their dependant families and even some members of the Samaru village. As reported, the operation of the plant is in accordance with the operating code of practice in the industry in

Nigeria. Despite its shortcomings, the plant operates to distribute treated water to the various hostels, classrooms, offices and households within the university community. In view of the incidence of other disinfection by-products including the regulated and unregulated disinfection by-products in the drinking water produced by the treatment plant, this study attempts to determine the type and level of haloacetonitriles if any in the finished and distributed drinking water.

Acetonitriles are a group of compounds known by the International Union of Pure and Applied Chemistry (IUPAC) as ethanenitriles. These compounds have boiling points ranging between 67<sup>o</sup> and 130<sup>o</sup>C. Among these compounds, four have been reported to be very common in drinking water. These are dichloroacetonitrile, dibromoacetonitrile, bromochloroacetonitrile, and trichloroacetonitrile (WHO, 2004). These halogenated acetonitriles (haloacetonitriles) are produced in the course of drinking water treatment when either chlorine or chloramine is used as disinfectant.

Like all other disinfection by-products, these haloacetonitriles are products of the reactions between either chlorine or chloramine as disinfectant with dissolved organic matter or its intermediate products of decomposition like fulvic acid, algae and proteinaceous materials. Apart from trichloroacetonitrile, these other three members readily undergo hydrolysis in water. This is responsible for their high degree of leaching losses from soils and transformation in water especially alkaline water. Typically, dibromoacetonitrile undergoes hydrolysis at a faster rate in water especially if such water is alkaline and in the presence of chlorine. However, these compounds are not known to undergo high degree of volatilization while adsorption to sediments and bioaccumulation in aquatic organisms are unexpected (WHO, 2004).

Generally, increasing temperature and/or decreasing pH are associated with increased levels of halogenated acetonitriles (AWWARF, 1991; Siddiqui and Amy, 1993; WHO, 2004; Liscomb *et al.*, 2009). These compounds are also known to form rapidly in the distribution system but also decay due to hydrolysis exhibiting two trends showing different stability patterns for dibromoacetonitrile and bromochloroacetonitrile. Peters *et al* (1990) reported that the concentration of dibromoacetonitrile in tap water was generally

20 – 50% of that at the treatment plants indicating the occurrence of decay of the compound as a result of hydrolysis which occurred during transport. The speciation of these halogenated acetonitriles was also reported to some degree with ambient bromide levels (IPCS, 2000).

Data on the halogenated acetonitriles are not adequate for overall assessment of their carcinogenicity (WHO, 2004). Despite observation by the WHO (2004) that haloacetonitriles do not readily undergo volatilization, sediment adsorption and rapid bioaccumulation, Lipscomb *et al* (2009) noted that human exposure occurs through consumption of finished drinking water accompanied with oral and dermal contact through swimming, bathing and other activities. They also observed that these compounds are implicated in radioactivity of gut tissues due to their covalent bonding and increased lipid peroxidation.

## MATERIALS AND METHOD

### Sampling

Two Hundred and fifty two (252) samples were taken in duplicates longitudinally and simultaneously along the treatment and distribution system of the ABU water treatment works from the Kubanni reservoir (source water) to an elevated Household (in Area E Quarters). These samples were taken between 2008 and 2010 of the raw water, water after sedimentation, water after chlorination and water in the booster station tanks. House level sample was taken from Area E House Number 20. These samples were taken in 60 ml glass vials with weighed quantities of ammonium chloride as de-chlorinating agent and stored at temperature of about 4<sup>o</sup>C or less in ice filled jugs in accordance with USEPA method 551.1 (USEPA, 1995)

### Analytical Methods

Analyses of the water samples for their haloacetonitrile content were in accordance with standard methods outlined in USEPA (1995) method 551.1 using methyl *tert*-butyl ether (MTBE) as the extractant. An Agilent Gas Chromatograph calibrated with commercial standards supplied by Ultra Scientific Analytical

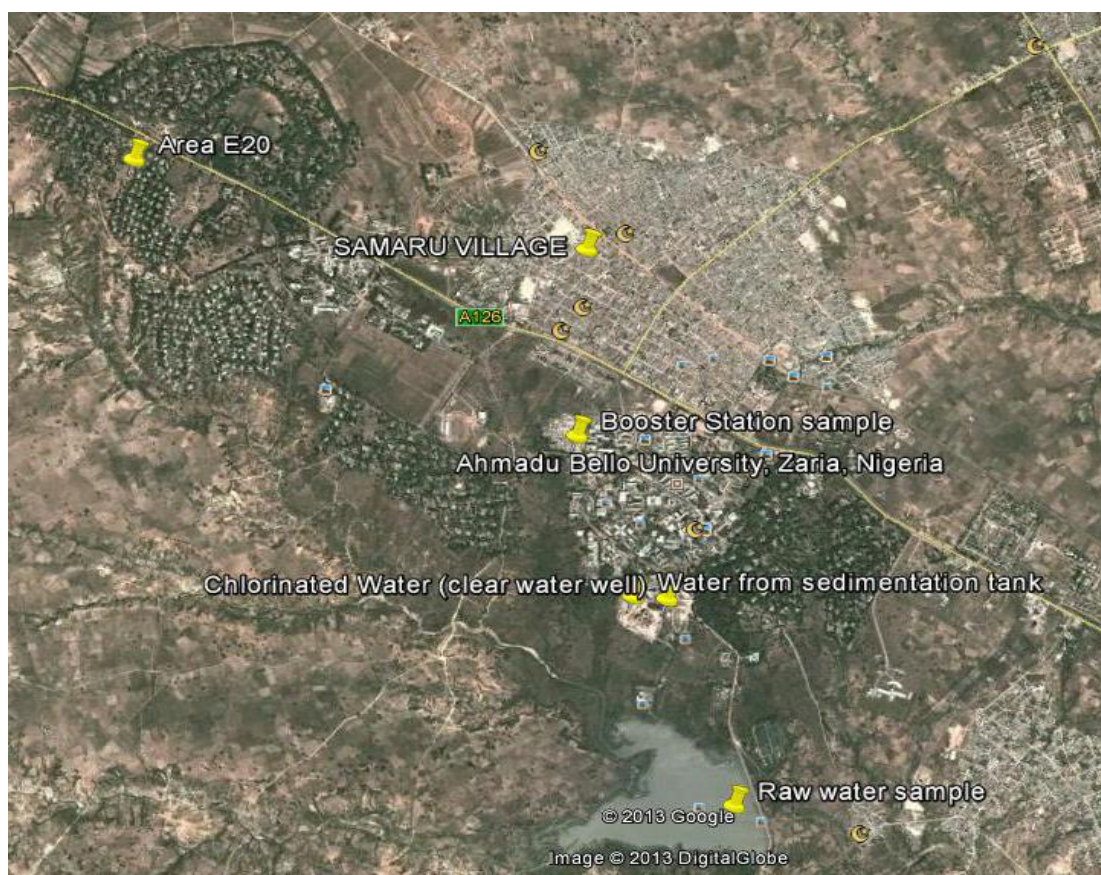
Solutions, North Kingstown, USA was used to measure the levels of concentrations of the haloacetonitriles in the samples. The results were later compared with national and international standards.

## Results and Discussions

The results of the physico-chemical parameters as determined in these analyses are presented in Tables 1 and 2 while the determined concentration levels of haloacetonitriles are presented in Table 3. Table 4 shows the results for regression analyses between the determined haloacetonitriles and some of the determined physico-chemical parameters. Over the three years period, the sampled water mean temperature values as obtained were relatively consistent among the five weather conditions over

the periods. The months of June and July when the rains are beginning to set in in the study area recorded the highest water mean temperatures averaging 22.8 °C in 2008, 24.1 °C in 2009 and 23 °C in 2010. On the other hand the *Harmattan* period recorded the least mean water temperatures of 18.1 °C, 16.7 °C and 18.2 °C for 2008, 2009, and 2010, respectively. These values are reflections of mean daily temperature values of the study area.

Other results of analysed physical parameters are presented in Table 2. From this table, the measured pH values of the treated and distributed water ranged between 7.80±0.98 after chlorination and 6.70±0.51 at household level. These values are within international acceptable limits for drinking water of slightly acidic to slightly alkaline range of pH values.



11°09'12.54" N 7°39'08.97" E

**Figure 1:** Google Map of the Sampling points for the Assessment of Haloacetonitriles - DBPs in Ahmadu Bello University Drinking Water Supply.



**Table 1:** Sampled Water Temperature Variations during the Sampling Periods.

Year	Jan-Feb (Beginning of Hot Season)	March - May (Mid Hot Season)	June July (Onset of Rains)	August - Sept (Peak Rainy Season)	Nov. - Dec. (Harmattan)
2008 ( <sup>o</sup> C)	12.3	21.8	22.8	22.8	18.1
2009 ( <sup>o</sup> C)	15.5	21.8	24.1	23.3	16.7
2010 ( <sup>o</sup> C)	15.8	22.6	23	22.8	18.2

**Table 2:** Mean Concentration Levels of Physico-chemical Parameters as Measured in the Water Samples from the Treatment and Distribution Systems of the ABU Waterworks.

Measurement	Raw Water	Water after Sedimentation	Water after Chlorination	Booster Station Water	Household water
pH	7.8 ±1.34	7.60±1.00	7.80±0.98	8.00±1.01	6.70±0.51
Conductivity (µS/cm @ 25 °C)	83.52±14.75	102.50±25.60	131.00±16.24	121.00± 30.81	102.00±27.30
Chlorides (mg/L)	12.30±3.59	0.80±0.16	12.65±4.06	0.50±0.11	0.50±0.087
Total Dissolved Solids TDS (mg/L)	50.50±10.97	50.50±9.96	51.50±9.88	55.00±14.52	66.00±7.02
Total Organic Carbon TOC (mg/L)	6.57±0.92	4.30±1.73	2.30±0.31	2.40±0.31	2.30±0.28
Residual Chlorine (mg/L)	0.00	0.00	0.05±0.016	0.03±0.016	0.02±0.014
Nitrates (mg/L)	3.00±0.54	2.40±0.54	0.80±0.28	0.80±0.30	1.40±0.50
Sulphates (mg/L)	40.00±11.55	23.00±1.09	22.50±1.35	24.50±2.99	42.00±5.90
Phosphates (mg/L)	0.39±0.021	0.15±0.019	0.25±0.026	0.15±0.017	0.10±0.012

The increase in acidity towards house level could be due to the intermittent distribution of the produced drinking water. This practice favors biofilms generation and subsequent decomposition creating organic intermediate products (Jakubovics, 1998; LeChevallier, 2000) which, on mineralization tend to acidify the medium (Shaibu-Imodagbe, 2011).

Conductivity mean values of the treated water were 131.00±16.21 µS/cm @ 25 °C in samples after chlorination and 102.00±27.30 µS/cm @ 25 °C in house level samples. These values are considerably lower than the maximum permitted level of 1000 µS/cm @ 25 °C. Highest values were obtained after chlorination in the treatment stage probably due to the calcium hypochlorite used as a disinfectant and the peak content of chlorides at this stage of treatment. The treated water also had higher mean concentrations of chlorides (12.65±4.06 mg/L) than the distributed water at household level (0.5±0.087 mg/L).

The variation in chlorides content may also not be unconnected with the disinfectant used at the

treatment stage. This is despite the initial high values in the raw water (12.30±3.59 mg/L) which had been precipitated at the sedimentation tanks.

The total dissolved solids (TDS) ranged from 50.50±10.97 mg/L in the raw water sample to 66.00±7.02 mg/L in the household water sample. The higher TDS values were recorded during the distribution of the treated water than during the treatment stage. This may initially be due to the use of flocculating and liming agents during the treatment stage; while the upsurge in the TDS concentration levels could be due to the products of the mineralization of the intermediate products of decomposed biofilms in the distribution system. The proportion of total organic carbon in the raw water (6.57±0.92 mg/L) and the treated water (2.30±0.31 mg/L) and distributed water to household level (2.30±0.28 mg/L) exceeded the maximum total organic carbon levels of 4 mg/L for source water and 2 mg/L for treated water specified in the Disinfectants and Disinfection By-Products Rule of the USEPA (Anon, 2001). This may have implications for disinfection by-

products formation during the drinking water treatment and distribution.

The mean concentrations of residual chlorine in the treatment and distribution system were found to vary from  $0.05 \pm 0.016$  mg/L in the samples after chlorination to  $0.02 \pm 0.014$  mg/L at household level. These low mean concentrations have implications for the safe delivery of wholesome and potable drinking water to the consuming community as these indicate low capacity to maintain secondary disinfection in the distribution system. The mean nitrate concentrations decreased longitudinally along the treatment process from  $3.00 \pm 0.54$  mg/L in the raw water to  $0.80 \pm 0.28$  mg/L in the sample after chlorination but increased slightly to  $1.40 \pm 0.5$  mg/L at house level probably due to the biofilm growth, decomposition and mineralization as a result of intermittent water distribution. These values are considerably lower than the maximum contaminant limit of 50 mg/L for nitrates allowed in national and international standards because of the risk of methaemoglobinanaemia.

The concentrations of sulphates were found to decrease during the treatment process from  $40.00 \pm 11.55$  mg/L to  $22.50 \pm 1.35$  mg/L after chlorination but gradually increased to  $42.00 \pm 5.90$  mg/L at household level. This situation is most probably accounted for by the growth, decomposition and mineralization of biofilms generated in the distribution system due to intermittent water distribution. Despite this, these values are still within acceptable limits under the national and international standards which range from 100 mg/L to 500 mg/L. The mean phosphate concentrations in the treatment and distribution stages progressively decreased from the raw water with  $0.39 \pm 0.021$  mg/L to house level water

with  $0.10 \pm 0.012$  mg/L. This trend may be connected to the sedimentation of phosphates in the sedimentation tanks and use of phosphates as essential nutrients for the growth and development of biofilms along the distribution system.

Mean concentrations of bromochloroacetonitrile ranged between below detection in the raw water and sedimentation samples to  $1.392E-02 \pm 6.1033E-06$  mg/L in the sample immediately after chlorination. This trend is due to absence of chlorine or chloramine disinfectant in the raw water sample and the sample from the sedimentation tanks. It was only after chlorination in the clear water well that noticeable concentration of bromochloroacetonitrile was detected in the sample. This is because disinfection process provided the chlorine that reacted with the fractions of naturally occurring substances such as algae, fulvic acid and proteinaceous materials in the water being treated to form the haloacetonitriles (bromochloroacetonitrile inclusive). Subsequently there were no traces of bromochloroacetonitrile in samples of the distributed treated water to the booster station and house level.

The absence of bromochloroacetonitrile in the distributed water samples could be due to its hydrolysis of the compound in the distributed water as had been observed for other haloacetonitrile (WHO, 2004). This situation could also be enhanced by the dynamic turbulent flow characteristics exhibited by the intermittent water releases into the distribution network. In view of the absence of bromochloroacetonitrile from the distributed water, the risk posed by this compound to consumers of this treated water is considered negligible or at best non-existent.

**Table 3:** Mean Concentration Levels of Haloacetonitriles (HANs) as determined in Samples of Drinking water Treated and Distributed by Ahmadu Bello University (ABU) Water Works

Measurement	Raw Water	Water after Sedimentation	Water after Chlorination	Booster Station Water	Household water
<i>Haloacetonitriles (mg/L)</i>					
Bromochloroaceto-nitrile (mg/L)	BD	BD	$1.3927E-02 \pm 6.1033E-06$	BD	BD
Dibromoacetonitrile (mg/L)	BD	BD	$1.0605E-02 \pm 3.3349E-05$	$2.4114E-02 \pm 5.4886E-05$	$2.4731E-02 \pm 5.2273E-04$
Dichloroacetonitrile (mg/L)	BD	BD	$1.6431E-03 \pm 1.4647E-06$	$1.3000E-03 \pm 3.7005E-05$	$2.2190E-03 \pm 1.8910E-06$
Trichloroacetonitrile (mg/L)	BD	BD	BD	BD	BD

BD = Below detection

Also among the observed haloacetonitriles in the Ahmadu Bello University treated drinking water is dibromoacetonitriles. Concentration levels of this compound were found to increase from the chlorination stage to household level. With a mean concentration of  $1.0605\text{E-}02\pm 3.3349\text{E-}05$  mg/L after chlorination this increased to  $2.4114\text{E-}02\pm 5.4886\text{E-}05$  mg/L.

Despite decreasing residual chlorine from  $0.05\pm 0.016$  mg/L to  $0.03\pm 0.016$  mg/L, from the chlorination stage to the booster tanks, the increase in dibromoacetonitrile could be likely due to the increase in total organic carbon (TOC) from  $2.30\pm 0.31$  mg/L in the water after chlorination to  $2.41\pm 0.31$  mg/L in the booster station tanks, (Anon, 2001). Further increase in the concentration level of the analyte to  $2.4731\text{E-}02\pm 5.2273\text{E-}04$  mg/L at house level water supply could be likely caused by increase in acidity (from  $8.00\pm 1.01$  in the booster station tanks to  $6.70\pm 0.51$  at house level samples) as reported by Siddiqui and Amy, (1993) and WHO, (2004). The occurrence of dibromoacetonitrile in the treated drinking water from the ABU water treatment plant results in consumption exposure from oral ingestion as well as dermal exposure from showering, bathing, swimming and washing. Like other haloacetonitriles, these exposure patterns aggravate dibromoacetonitrile toxicity to gastrointestinal tissues, from oral contact that causes glutathione (GSH) depletion, increased lipid peroxidation and covalent binding associated with haloacetonitrile related radioactivity to gut tissues (Lipscomb *et al*, 2009). This is despite the fact that dibromoacetonitriles and other haloacetonitriles in drinking water are extensively absorbed and metabolized in the gastrointestinal tract.

The depletion of GSH removes the protective layer provided by GSH against haloacetonitrile toxicity including their associated radioactivity from scavenging reactive oxygen species (ROS) that are produced in gut tissues. There is also evidence from in vitro sources that these ROS are involved in the degradation and formation of reactive intermediates of haloacetonitriles including those responsible for radiolabel found to be covalently bound to proteins and DNA in several organs and tissues (WHO, 2008; Lipscomb *et al* 2009).

Dichloroacetonitrile was detected in the treated water after chlorination as with other haloacetonitriles. Its mean concentration was

$1.6431\text{E-}03\pm 1.4647\text{E-}06$  mg/L in the treated water after chlorination. This decreased to  $1.3000\text{E-}03\pm 3.7005\text{E-}05$  mg/L in the distributed water in the booster station tanks. This reduction could be due to the turbulent flow regime and the increase in the pH from  $7.8\pm 0.98$  to  $8.00\pm 1.01$  (a reduction in acidity) that decreases the formation potential of haloacetonitriles and other disinfection by-products (Siddiqui and Amy, (1993); WHO, (2004)). However, from the booster station tanks to house level, there was recorded an increase in the concentration level of dichloroacetonitrile from  $1.3000\text{E-}03\pm 3.7005\text{E-}05$  to  $2.2190\text{E-}03\pm 1.8910\text{E-}06$  mg/L. This increase could be due to increase in acidity (reduction in pH values from  $8.00\pm 1.01$  in the booster station to  $6.70\pm 0.51$  at house level) despite a reduction in the total organic carbon (from  $2.41\pm 0.28$  mg/L in the booster station to  $2.30$  mg/L at house level and reduced residual chlorine from  $0.03\pm 0.016$  mg/L to  $0.02\pm 0.016$  mg/L).

From the foregoing it is indicative that increasing acidity and total organic carbon contents are predominantly responsible for determining the increases in the mean concentration levels of haloacetonitriles in drinking water supplies. Despite these trends, the determined levels of the haloacetonitriles are lower than the provisional WHO guidelines for the compounds in the treated water from the ABU Water treatment plant –  $0.07$  mg/L for dibromoacetonitrile and  $0.02$  mg/L for dichloroacetonitrile, (WHO, 2008).

The slight increase over the provisional guideline value at household level for dichloroacetonitrile would require a diligent management of the distribution of drinking water through uninterrupted supply to effectively check the growth of biofilms whose decomposition and mineralization produce acid intermediates that possibly increase the acidity of the drinking water reaching residential household levels. Acidity has since been identified as a favourable factor increasing most disinfection by-products including haloacetonitriles (Siddiqui and Amy, 1993) This is without prejudice to the provisional guideline recommendation that individual haloacetonitrile could have concentration which exceed  $0.01$  mg/L even though they usually occur at levels of  $0.002$  mg/L or less (WHO 2008).

Despite being identified as one of the common haloacetonitriles in chlorinated drinking water, this study did not find trichloroacetonitrile in either

the treated or distributed drinking water to households by the ABU water treatment plant. However further studies and monitoring for this compound in the ABU treated and distributed would be necessary to support this.

Furthermore, the total mean concentrations of the haloacetonitriles were subjected to linear regression analyses with some of the physico-chemical properties of the sampled waters using Microsoft Excel (2010 edition). This was to determine the degree of significance if any in the proportion of the mean total haloacetonitriles brought about by changes in the proportions of these various physico-chemical parameters.

Table 4 shows the list of six of these physico-chemical parameters which gave linear regression coefficients with significant “F” values at a minimum of 95 percent confidence limit. The list included the physico-chemical parameters which are generally accepted to influence the proportions of disinfection by-products in drinking water. It is therefore possible to infer that this

study was sensitive enough to identify the influence of most of the influencing physico-chemical parameters (temperature, pH, total organic carbon, total dissolved solids and residual chlorine already identified in literature) on disinfection by-products with respect to the total haloacetonitriles. From these, predictive models were computed to show the dependent relationships these haloacetonitriles have on seasonality and the listed physico-chemical parameters.

In these relationship assessments, it is noteworthy that both the temperature and the season significantly influenced the levels of total haloacetonitriles. This shows that the degree of hotness and the duration of hotness within the period 2008 to 2010 significantly affected the levels of mean total haloacetonitriles in sampled drinking water produced and distributed by the ABU drinking water treatment plant. However, additional studies are recommended to enhance the reliability of interpolation and extrapolation of these results.

**Table 4:** Regression Characteristics of Haloacetonitriles and Physico-Chemical Parameters of the ABU Drinking Water Samples.

Variables		Regression Coefficient (R <sup>2</sup> )	ANOVA F values	Significant F	Regression Model
X	Y				
Temperature	Total Mean Trihaloacetonitriles (TTHANs)	0.171341	0.620306*	0.4730	y = 3E-06x + 0.0101
Season	Total Mean Trihaloacetonitriles (TTHANs)	0.1716	0.621518*	0.488039	Y = 7E-05x + 0.0772
pH	Total Mean Trihaloacetonitriles (TTHANs)	0.564766	3.89284**	0.1221	y = -2E-05x + 0.0103
Total Dissolved Solids (TDS)	Total Mean Trihaloacetonitriles (TTHANs)	0.698692	6.95658**	0.1396	y = 2E-06x + 0.0100
Total Organic Carbon (TOC)	Total Mean Trihaloacetonitriles (TTHANs)	0.810097	12.7976**	0.0844	y = 3E-05x + 0.0100
Residual Chlorine	Total Mean Trihaloacetonitriles (TTHANs)	0.602189	4.54126**	0.2538	y = 3E-04x + 0.0101

## CONCLUSION

In this study, three of the four commonly observed haloacetonitriles were observed in the community drinking water supplied by the ABU water treatment plant. These were bromochloroacetonitrile, dibromoacetonitrile and dichloroacetonitrile that were detected while trichloroacetonitrile was not detected in the drinking water. While the mean concentration of  $1.3927\text{E-}02 \pm 6.1033\text{E-}06$  mg/L of bromochloroacetonitrile was detected in the treated water, none was detected in the water being distributed into the booster station and to household level. On the other hand, dibromoacetonitrile and dichloroacetonitrile were detected to have concentrations which increased to house levels a situation that was possibly due to the increasing acidity of the distributed water towards house levels. Ranges of concentrations were  $1.0605\text{E-}02 \pm 3.3349\text{E-}05$  mg/L to  $2.4731\text{E-}02 \pm 5.2273\text{E-}04$  mg/L for dibromoacetonitrile and  $1.3000\text{E-}03 \pm 3.7005\text{E-}05$  mg/L to  $2.2190\text{E-}03 \pm 1.8910\text{E-}06$  mg/L for dichloroacetonitrile.

Although these emerging disinfection by-products are not regulated in Nigeria and internationally, the absence of bromochloroacetonitrile in the ABU treated and distributed drinking water at house level poses little or no risk to consumers of the drinking water from bromochloroacetonitrile. The mean values of dibromoacetonitrile in the treated and distributed water are well within the WHO provisional guideline recommendation for the compound (0.07 mg/L) even though dichloroacetonitrile mean level exceeded the WHO provisional recommended concentration of 0.02 mg/L at house level. These could have the implication of increasing the associated risks of glutathione (GSH) depletion coupled with increased lipid peroxidation and covalent bond associated with haloacetonitrile related radioactivity and associated toxicity from scavenging reactive oxygen (ROS) from the consumption of the treated and distributed water (WHO, 2008; Lipscomb *et al* 2009). This requires a constant effort to minimise the concentration of these emerging DBPs in the treated water by reducing the DBP precursors, through source water protection from wastewater discharges from Samaru village and effluent from waste dump behind Ramat/Interim Common Services Agency (ICSA) hostels.

Also, an uninterrupted flow of treated water into the booster station and distribution mains will

control the growth of biofilms which add to the total organic carbon (TOC) content when these decompose into the system. Statistically, the range of measured total mean haloacetonitriles showed significant linear regression with temperature, seasonality (2008 – 2010), pH, total dissolved solids, total organic carbon and the residual chlorine of the sampled waters. These generated predictive models which could be safely interpolated to predict the levels of these haloacetonitriles at any pre-determined conditions of these independent physico-chemical variables (temperature, pH, total dissolved solids, total organic carbon and residual chlorine) of the ABU treated drinking water during the sampling period. However, care must be taken in extrapolating the results of these models to the treated drinking water outside the sampling period and indeed to other drinking water supplies unless backed with additional sampling and assessment.

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