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Assessment of the Quality of Water Treated and Distributed By the Akwa Ibom State Water Company

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Abstract: The quality of water treated and distributed by the Akwa Ibom Water Company has been assessed by analyzing samples of water collected from different distribution points for their physiochemical parameters, major ions, nutrients and bacteriological quality. The observed values were compared with standard values given by the World Health Organization for portable water. The quality of the analysed water is found fit for human consumption.

Keywords: Akwa Ibom water company, water quality assessment

Introduction

Water is the basis of all life - an ecological resource for the flora and fauna of our earth and a fundamental necessity for human life. Without an adequate supply of safe water, we have no hope of improving the health of the people in our partner countries[1]. The WHO[1] estimates that 80% of all disease is in some way connected with contaminated water. Without a well-functioning water supply it is difficult to imagine productive human activity, be it agriculture or forestry, livestock farming or fisheries, trade or industry. Water is thus becoming a crucial factor for development and the quality of life in many countries. In individual arid areas it has even become a survival factor.

According to the WHO/UNEP [2], the problems associated with the lack of adequate and quality water resources in Nigeria have threaten to place the health of about 40 million people at risk. The latest World Bank studies suggest that it would cost an excess of US$ 10^9 a year (About N142 $x10^9$) to correct such problems if ground and surface water contamination goes unchecked.

Because of the threat to the hydrosphere, in 1988, the then Federal Military Government of Nigeria placed great importance on the environment and established the Federal Environmental Protection Agency (FEPA) [3] by Decree 58 of 30 December 1988. The FEPA has statutory responsibility of ensuring the protection of the environment.

In Akwa Ibom State, past and previous governments have not be left out with the problem of water supply for example, in 1989, the Akwa Ibom State water cooperation was established with the major responsibility of providing safe and portable water for the people of the state. There are more than 20 boreholes sunk, prepare and mange by the Akwa Ibom State water Board. However, the management of these projects has been transfer to the newly established Akwa Ibom State water Company. The treatment method adopted by the company includes steps shown by Figure 1.

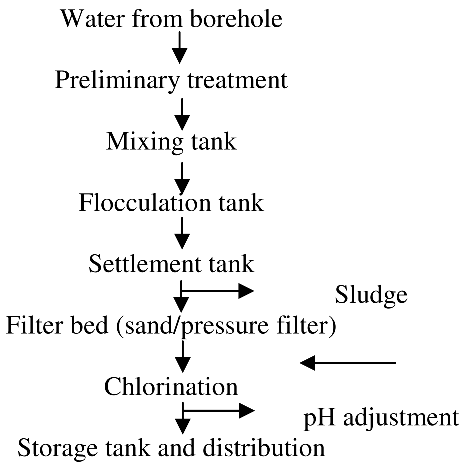

Figure 1. Flow sheet showing steps used in treating water by Akwa Ibom Water Company

UNEP/WHO [2] defines water quality as its fitness for the beneficial uses, which it has provided for drinking by man and animals, for the support of marine life, for irrigation, for industry, for recreation and for aesthetic purposes. The present study is aimed at assessing the effectiveness of these treatment methods on the quality of water supply to consumers.

Experimental

Materials and methods

Samples of pipe borne water were collected from ten locations (distribution outlets) within Akwa Ibom State. Each sample was preserved in plastic container prior to analysis.

The colour of the water sample was determined by using the colour meter. The sample was inserted into the sample compartment of the meter and the colour of the sample was read in Hazen unit [4]. In order to determine the pH of the water, Orion model 520 pH meter was used. The meter was first calibrated using three technical buffers (pH = 1.65, 7.00 and 10.00) after which the probe of the meter was inserted into the sample and the pH was read directly from the system's read out meter. The conductivity of the water was determined by dipping the probe of the conductivity meter into the sample followed by the reading of the conductivity in µS/cm unit. The temperature of the water was determined by using mercury in glass thermometer. The phenolphthalein, total alkalinity, residual chlorine content, and chloride content of the water were determined by titrimetric analysis as reported in Ademoroti [4] and A. O. A. C.[5]. The turbidity of the sample was determined by using a turbidity meter while the salinity of the water was determined by multiplying the concentration of chloride in the sample by a conversion factor [6]. The concentration of iron, copper, calcium, manganese, BOD, ammonia, sodium, potassium, phosphate, calcium/magnesium hardness, DO, nitrite, nitrate, sulphate, TDS and SS were determined by using arc water spectrophotometer. Water sample was introduced into the meter's cuvette and each parameter was determined by setting the system to the required stored programme number of the respective parameter to be measured.

Results and Discussion

The result of the physiochemical parameters of the treated water is as shown by Table 1 to 4. It can be seen that the concentrations of the respective parameters are below the WHO [1] standard as shown by table 2. The standard deviations for each of the data set are also indicated in the respective table.

Table 1. Major ions in the treated water

Major ions	Mean± Standard deviation	*WHO standard
Total iron (Fe^{3+}) (mg/L)	0.29 ±0.001	0.36
Copper (Cu^{2+})	0.00 ±0.00	
Sodium (Na^{+})	1.63 ± 0.007	200.00
Potassium (K^{+})	0.57 ± 0.009	150.00
Sulphate (SO_4^{2-}) (mg/L)	1.90 ±0.009	42.00-45.00
Magnesium (Mg^{2+})	1.58 ±0.005	50.00-150.00
Calcium (Ca^{2+})	8.58 ±0.004	75.00
Manganese (Mn^{2+})	0.00 ± 0.00	0.10

Table 2. Physiochemical parameters of treated pipe borne water

Physical parameter	Mean ± SD	*WHO STD
Appearance	Clear	Clear
Colour (Hazen unit)	5.0 ± 0.00	5.0 – 15
Odour	Inoffensive	Inoffensive
Temperature (°C)	26.57 ± 0.061	27.0 –28.0
pH	6.82 ± 0.0057	6.5-8.5
Conductivity (µS/cm)	29.80 ± 0.005	1000.00
Turbidity	0.25 ± 0.007	5.0
Residual chlorine (mg/L)	0.75 ± 0.001	-
Total alkalinity (mg/L)	1.77 ± 0.002	100-200
Phenolphthalein alkalinity (mg/L)	0.0± 0.00	-
Methyl orange alkalinity (mg/L)	1.77 ± 0.002	-
Salinity	12.83 ± 0.001	-
Total hardness (mg/L)	0.45 ± 0.001	500.00
Dissolve oxygen (mg/L)	1.0 ± 0.0001	1.0-5.0
Free carbon (IV) oxide	14.83 ± 0.003	-
Total dissolve solid (mg/L)	0.05 ± 0.007	1000.00
Biochemical oxygen demand	0.09 ± 0.001	-
Ammonia (mg/L)		0.2-0.5

Table 3. Nutrient content of treated pipe borne water

Nutrient	Mean ± standard deviation	*WHO standard
Nitrite (mg/L)	3.26 ± 0.009	< 1.0
Nitrate (mg/L)	0.90 ± 0.00	10.0
Phosphate (mg/L)	0.12 ± 0.007	3.50

Table 4. Bacteriological quality of the water

Nutrient	Mean ± standard deviation	*WHO standard
E-coli,	Nil	Nil
Facceal streptococci,	Nil	Nil
Clostridium Perfringens	Nil	Nil
total Coliform.	Nil	Nil

The colours of all the water samples were each found to be 5.00 Hazen unit. This value correspond to standard value therefore the water is not polluted with respect to colour. The significant of colour on the quality of water has been extensively discussed and published by Ademoroti [4] and Dara [7]. The appearance of the water and its odour were within acceptable quality when compared with the WHO requirement [1].

According to Eddy and Udoh [8], the colour of any water sample depends on the amount and types of soluble ions (especially cations). A treatment method that may likely present the colour of the water within acceptable range is coagulation. This process can coagulate iron and removed it in form of colloids as exemplified by Eq. 1 and 2

$$Al^{3+} + (Colloids)^{n} \rightleftharpoons Al\ (Colloid)^{3n} \quad (1)$$

$$Fe^{3+} + (Colloids)^{n} \rightleftharpoons Fe(Colloid)^{3n} \quad (2)$$

The odour of most water bodies is mostly attributed to the amount of organic matter present in the water for example, ammonia is a product of decomposition of organic mater and when present in water, it gives offensive odour. The acceptable colour presented by the treated water shows that treatment measures adopted by the Akwa Ibom state Water Company is effective in giving the water, a good colour. This method includes biological clarification, aerobic oxidation, anaerobic oxidation, autolysis and nitration.

During biological clarification, organic matters are converted to their highly oxidized inorganic forms by bacteria (Eq. 3-7)

$$\text{Organic–H} + \text{oxygen} \rightleftharpoons \text{water} \quad (3)$$

$$\text{Organic carbon} + \text{oxygen} \rightleftharpoons \text{carbon (IV) oxide} \quad (4)$$

$$\text{Organic nitrogen} + \text{oxygen} \rightleftharpoons \text{Trioxonitrate (V) compounds} \quad (5)$$

$$\text{Organic sulphur} + \text{oxygen} \rightleftharpoons \text{Tetraoxosulphate (VI) compound} \quad (6)$$

$$\text{Organic phosphorus} + \text{oxygen} \rightleftharpoons \text{tetraoxosulphate (VI) compound} \quad (7)$$

Aerobic oxidation may takes place via catabolism as shown by equation 8, anabolism (Eq. 9) or autolysis (Eq. 10)

$$C_xH_yO_2N \rightleftharpoons CO_2 + H_2O + NH_3 + \text{energy} \quad (8)$$

$$C_xH_yO_2N + \text{energy} \rightleftharpoons C_5H_7NO_2 \quad (9)$$

$$C_xH_yO_2N\ 5O_2 \rightleftharpoons 5CO_2 + NH_3 + 2H_2O + \text{energy} \quad (10)$$

These three processes can remove most organic compounds from the water [12].

Anaerobic oxidation takes place in the absent of oxygen and is aimed at breaking down complex organic compounds as shown by Eq. 11 and 12

$$C_3H_7O_2NS + 8H_2O \rightleftharpoons 4CH_3COOH + 4CO_2 + 4NH_3 + 4H_2S + 8H^+ \quad (11)$$

$$4CH_3COOH + 8H^+ \rightleftharpoons 5CH_4 + 3CO_2 + 2H_2O \quad (12)$$

Nitration is aimed at hydrolyzing urea, oxidation of ammonia and the oxidation of nitrite to nitrate as shown by Eq. 13 to 15

$$NH_2CONH_2 + H_2O \rightleftharpoons 2NH_3 + CO_2 \quad (13)$$

$$55NH_3 + 76O_2 + 5CO_2 \rightleftharpoons C_5H_7NO_2 + 54NO_2^- + 52H_2O + 54H^+ \quad (14)$$

$$400NO_2^+ + 195O_2 + 52CO_2 + NH_3 + 2H_2O \rightleftharpoons C_5H_7NO_2 + 400NO_3^- \quad (15)$$

The above treatment steps is capable of adjusting the physiochemical parameters, nutrient , heavy metals and bacteria content of the water. The observed temperature of the water were below the standard value given by WHO [10] implying implies that the water is not affected by thermal pollution

The iron content of the water samples ranged from 0.02 – 0.03 mg/L (mean = 0.293mg/L). Water quality criterion requires permissible iron content of drinking water not to be above 0.3mg/L. Therefore the water samples are not polluted with respect to iron.

The turbidities of all the water samples were within the permissible criteria (WHO, 1984). Also, the mean electrical conductivity of the water did not exceed the standard value required by WHO for portable water. This implies that the water is not polluted with respect to conductivity. The measured low conductivity values shows that these samples contain little amount of electrolyte (including chloride and $CaCO_3$) [9]. The mean chloride content of samples did not exceed the maximum tolerance limit of 600 mg/L required for drinking water [1].. In terms of level of hardness, the water can be regarded as been soft [4]. Low values for the chloride and hardness of the water also confirms the significant of the measured values of conductivity which were generally low. In most water, electrolytes are present in the form of soluble metallic salts (such as NO_3^-, NO_2^-, Cl^-)[10].

In the analyzed water samples, the concentration of nitrite and nitrate were below the permissible criteria [1,3]. The reduced concentration of nitrate might have been due to the removal of nitrate salt during the filtration process. The major sources of nitrate pollution are domestic waste, industrial waste, sewage, sludge *etc.*[3,4]. Other processes apart from those highlighted above might have contributed to the nitrate content of underground water. During their research on the quality of underground water in Uyo as they affect the production of package water, Eddy and Ekop [11] found out that most producers of packaged water uses water from boreholes as their primary raw materials and that nitrate contamination is most likely if the treatment methods is not designed to removed excessive nitrate from the water. The treatment method adopted by the Akwa Ibom Water Company is therefore effective in removing nitrate contaminants. The toxic effect of excessive concentration of nitrate on human beings has been extensively discussed by Ademoroti[4]. Eddy [5] and Dara [7]

The total alkalinity of the water samples was below the permissible and desirable criteria for domestic water supply[3]. The observed alkalinity was due to methyl orange alkalinity since phenolphthalein alkalinities were zero in all the water samples. Consequently, the water samples are not polluted with respect to alkalinity. The concentration of dissolved oxygen, CO_2, TDS, chloride, potassium, sodium and turbidity of the water were also below the permissible and desirable criteria for domestic water supply[1,3,4] implying that the treatment process adopted by the company is effective in bringing down the concentration of these parameters

The concentration of ammonia in the water samples ranged from 0.02mg/L to 0.20mg/L. The desirable criterion is 0 mg/L while the WHO standard for the concentration of ammonia in water is 0.2-0.5mg/L . This implies the water is polluted when the concentration of ammonia is compared with the desirable criteria. However, the values obtained for the concentration of ammonia in the entire water sample are below the WHO standard. Source of ammonia-polluted water include domestic waste, decomposition of nitrogenous compound and industrial effluents. In underground water, these sources are effective when the ammonia nitrogen containing materials can be leached or seep in solution into the ground. The pollution effects of ammonia have been extensively reviewed and published by UNEP/WHO[2],FEPA [3] and Dara[7].

The bacteria species analysed in water samples were E-coli, facceal streptococci, clostridium Perfringens and total coliform. These were completely absent in the sample. The termination of microbial life in the analysed water sample is due to chlorination[7] chlorination during the resident time of the water in the treatment tank (Eq. 16 to18).

$$Ca(OCl)_2 \rightleftharpoons Ca^{2+} + 2OCl^- \quad (16)$$

$$OCl^- + H_2O \rightleftharpoons HOCl + OH^- \quad (17)$$

$$HOCl \rightleftharpoons H^+ + OCl^- \quad (18)$$

From the above equations, it can be seen that HOCl is the prime disinfecting agent. Eddy and Udoh [8] stated that the disinfection action of HOCl is pH dependent and functions best at pH range of 6.0 to 8.5. The measured pH of the water samples fall within this range (Table 2).

From the point of view of bacteriological quality of water, it is desirable and permitted that *E.coli* and coliform bacteria should not be present in water meant for consumption[12]**.** The bacteriological quality of the water confirm that the water is fit for drinking.

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