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Assessment of the Quality of Packaged Water in Uyo Metropolis: South Eastern Nigeria

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Abstract

In order to evaluate the quality of six types of water samples produced and marketed in Akwa Ibom State, five samples, each (from different manufacturers) of sachet and bottled water were randomly purchased from sellers within Uyo metropolis. The samples were analysed for their Physical parameters (appearance, colour, odour, temperature, pH, turbidity and electrical conductivity), major ions (sodium, potassium and total iron), chemical parameters (total alkalinity, phenolphthalein alkalinity, methyl orange alkalinity, chloride, total hardness, dissolved oxygen, carbon (IV) oxide, nitrate, nitrite, total dissolved solid and ammonium) and bacteriological parameters (E-coli, faecal streptococci, clostridium perfringens and total coliform). The analytical results were compared with permissible and desirable quality criteria and it was found that all the water samples are fit for consumption if the concentration of ammonium, nitrate, conductivity and the bacteriological quality of the water is improved.

Keywords: Water quality, sachet and bottled water, Uyo metropolis, South Eastern Nigeria

1. Introduction

The production, distribution and consumption of sachet water in most parts of Nigeria are on the increase. This may be attributed to the high demand for quality water and the cold water when the temperature of the atmosphere is high. Water quality refers to its fitness for the different purposes in which the water can be put to use [1, 2]. The AWWA [3] also defines water quality as those chemical, physical or biological characteristics by which the user evaluates the acceptability of the water. The quality of water can be assessed by examining its physiochemical parameters, organoleptic properties, gross organic parameters, radionuclides, heavy metals and bacteriological parameters [4-6]. The use of water for drinking purposes is perhaps the most essential usage that should be given adequate attention because this may directly affect the health and well-being of human beings. Reported cases of different types of sickness associated with the consumption of polluted water have been documented to include cholera, diarrhoea, hepatitis, dysentery, etc [7-9]. Water plays a major biochemical role in living things. It provides a medium for the transportation, assimilation and utilisation of important nutrients in human beings [10]. This implies that if the water is polluted, biochemical processes in the body may be hindered. For example, the presence of lead (Pb) in water has been confirmed to hinder the utilisation of some essential elements such as calcium and magnesium [11]. Water that is not suitable for consumption is polluted [6]. Polluted water contains substances in such an amount that it affects it judicious utilisation.

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Several studies have been conducted on the pollution of water by industrial and domestic wastes, natural and anthropogenic activities and the impact of such pollution have been found to grossly affect the ecosystem [4-6]. In most of these studies, water quality is assessed in terms of their physicochemical parameters and heavy metal content. The present study is aimed at assessing the physicochemical parameters (temperature, colour and appearance, odour, turbidity, electrical conductivity, pH, alkalinity, chloride content, nitrate, salinity, total hardness, dissolve oxygen, free carbon (IV) oxide, nitride, ammonia and total dissolved solid), major ions (calcium, sodium and magnesium, total iron) and bacteriological quality (coliform bacteria, faecial streptococcus and clostridiumv perfringens) of sachet and bottled water samples produced and marketed within Uyo metropolis, Akwa Ibom State.

2. Materials and Methods

Five samples each of Divine water (A), Majesty water (B), Prime water (C), Usmer water (D), Harmony water (E) and Ragolis water (F) randomly purchased from street sellers within Uyo municipality. The colour and physical appearance of the water samples were determined by using Nesslerier Disc NSA colour comparator [12]. The odour was observed by inhaling the water sample [13]. The temperature of the water was determined by using mercury in glass thermometer [14]. The turbidity of the water sample was determined by using turbidometer, Jenway Model 6035, while the electrical conductivity of the water was determined by using HACH conductivity meter, model 44600. The pH of the sample was measured using Jenway pH meter model 3305 [12].

The total iron and calcium contents of the water were determined using atomic absorption spectrophotometer (AAS) [15, 16]. The concentration of potassium and sodium in the water samples was determined using Jenway flame photometer model PFP60 [15]. The chloride content of the water was determined by titrating the water sample with 0.012 M $AgNO_3$ to potassium chromate end point [13]. The concentration of nitrite, ammonia and nitrate in the water sample was determined by colorimetry [12]. The total hardness of the water was determined by EDTA titration [13]. The dissolved oxygen content of the water was determined by using oxygen meter, model 14D-1A [12]. The concentration of CO_2 in the water was determined by titration with 0.05 M NaOH to phenolphthalein end point [13]. The total dissolved solid content of the water was determined by using HACH meter model 3305 [12] while the bacteriological analysis of the water sample was done by the method reported by Ademoroti [13].

3. Results and Discussions

The result of the analysis is presented in Table 1. The required standard value for each parameter is also presented in the table. All water samples were found to be polluted with respect to colour. The significant of colour on the quality of the water has been extensively discussed and published by Ademoroti [5] and Dara [11]. The appearance of the water and the odour were within acceptable quality when compared with the requirement for standards [17]. The observed temperatures of the water were fairly below the standard value of 26.4^{o}C [17-19]. The mean iron content of samples A, B, C, D, E and F were respectively equal to 0.002 mg/L, while that of sample F was 0.03 mg/L. The water quality criterion requires that the permissible iron content of drinking water should not be above 0.3 mg/L. Therefore, the analysed samples are not polluted with respect to the iron content.

The turbidities of all the water samples were within the permissible criteria [18, 19] indicating that the water samples is free from particulate matter. The mean electrical conductivity of sample B (187.80) and E (9104.10) exceeded the standard value of 75 Ms/cm given by WHO [17]. This suggests that the water is polluted with respect to conductivity. The observed high conductivities of samples B and E suggest that these samples contain excessive amount of electrolyte such as chloride and $CaCO_3$ [9, 20]. However, the chloride content of samples B (6.20 mg/L) did not exceed the maximum tolerance limit of 600 mg/L required for drinking water [17]. These samples B and E were observed to be moderately soft as compared to other samples, which are soft [5]. This suggests that the high conductivity of the water might have been partly contributed by the concentration of $CaCO_3$ and other electrolytes present in the water. In most water, samples electrolytes are present in the form of soluble metallic salts such as NO_3, NO_2 and Cl^- [21]. In the analysed water samples, the concentration of nitrite and nitrate were above the 10 mg/L permissible criteria [17-19]. Since the desirable criterion for both nitrate and nitrite is zero [17-19], it can be stated that all the water samples are polluted with respect to nitrate. The major source of nitrate pollution is domestic waste, industrial waste, sewage, sludge, etc [19]. The excessive nitrate content of the water might have been due to the primary sources in which most of the water was gotten from. In a survey carried out by the authors, it was observed that most of the producers of packaged water use water from boreholes as their primary raw materials. The likelihood of nitrate contamination might be manifested if the purification process was not designed to remove excessive nitrate from the water. According to Park [20], the guideline value for nitrate is aimed at protecting methamoglobinaemia which depends on the conversion of nitrate into nitrite. Park [20] also stated that the optimum requirement is that Equation 1 should be less than or equal to 1.

$$\frac{C_{nitrate}}{G_{nitrate}} + \frac{C_{nitrite}}{G_{nitrite}} \leq 1 \qquad 1$$

where $C_{nitrate}$ and $C_{nitrite}$ are the concentrations of nitrate and nitrite, respectively while $G_{nitrate}$ and $G_{nitrite}$ are the guideline values for nitrate and nitrite, respectively. From the present data, it is obvious that Equation 1 is less than unity. Therefore, contamination of the studied water samples by nitrite and nitrate will not pose serious health effect.

Table 1. Mean Concentration of Physicochemical Parameters and Major Ions in Sachet and Bottled Water.

Parameters	**A**	**B**	**C**	**D**	**E**	**F**	**Permissible limit (WHO, 1984)**
Physical parameters							
Appearance	ND	ND	ND	ND	ND	ND	-
Colour (Hazen unit)	5.00 ±0.06	5.00±004	5.00±0.00	5.00±0.20	5.00±0.10	5.00±0.12	5
Odour	ND	ND	ND	ND	ND	ND	-
Temperature (^oC)	28.20±0.02	28.40±003	28.60±0.04	28.90±1.22	28.00±0.59	28.10±0.23	29.4
pH	6.40 ± 0.01	6.00±0.01	8.40±0.02	7.60±0.34	5.80±0.22	7.30±021	6-8
Turbidity(NTU)	0.32±0.01	0.27±0.01	0.41±0.00	0.36±0.01	0.23±0.01	0.30±0.01	1
Electrical Conductivity	68.80±0.01	187.80±0.01	69.90±1.21	68.30±0.98	104.10±1.22	73.00±2.34	75
Major ions							
Sodium (mg/L)	8.00±0.69	15.00±0.054	2.00	2.00	10.00	15.00	200
Potassium (mg/L)	0.20±0.001	0.80±0.02	0.50±0.12	0.20±0.10	0.20±0.00	0.10±0.00	-
Total iron (mg/L)	0.02±0.001	0.02±0.01	0.02±0.00	0.02±0.00	0.02±0.00	0.03±0.00	0.3
Total alkalinity (mg/L)	1.00±0.02	3.00±0.01	1.00±0.00	2.00±0.00	1.00±0.01	2.00±0.03	30-50
PA (mg/L)	0.00±0.00	0.00±00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	-
MOA (mg/L)	1.00±0.01	3.00±0.02	1.00±0.00	2.00±0.23	1.00±0.00	2.00±0.67	-
Chloride (mg/L)	6.00±0.39	6.20±0.23	7.00±0.10	5.50±0.97	6.10±0.88	6.80±0.78	600
Total hardness (mg/L)	22.00±1.67	97.00±0.98	33.00±0.74	48.00±0.62	97.00±0.98	26.00±1.00	100
DO (mg/L)	0.11±0.00	0.12±0.01	0.10±0.00	0.12±0.02	0.14±0.03	0.10±0.00	4
CO_2 (mg/L)	1.00±0.00	0.50±0.01	0.50±0.04	0.50±0.04	0.57±0.05	0.50±0.07	-
Nitrate (mg/L)	0.10±0.01	0.15±0.00	0.13±0.01	0.18±0.01	0.12±0.00	0.15±001	10
TDS (mg/L)	34.60±0.91	94.20±0.81	34.90±0.99	34.10±0.06	52.10±0.06	39.20±0.08	500
Ammonium (mg/L)	0.15±0.06	0.13±0.03	0.10±0.01	0.20±0.01	0.22±0.00	0.12±0.00	0.1
Nitrite (mg/L)	0.02±0.00	0.05±0.00	0.02±0.00	0.04±0.00	0.01	0.06	1.0
Bacteriological parameters							
E-coli	Nill	Nill	Nill	Nill	Nill	Nill	Nill
faecal streptococci,	Nill	Nill	Nill	Nill	Nill	Nill	Nill
clostridium perfringens	Nill	Nill	Nill	Nill	Nill	Nill	Nill
total coliform	Nill	Nill	Nill	Nill	Nill	Nill	Nill

The total alkalinity of the water samples was significantly below permissible and desirable criteria for domestic water supply [19]. The observed alkalinity was due to methyl orange alkalinity (MOA) because phenolphthalein alkalinities (PA) were zero in all the water samples. Consequently, the water samples are not polluted with respect to alkalinity. The concentration of dissolved oxygen (DO), CO_2, total dissolved solid (TDS), chloride, potassium, sodium and turbidity of the water were also below the permissible and desirable criteria for domestic water supply [17-19].

The concentration of ammonia in the water samples ranged from 0.10 mg/L (in sample C) to 0.22 mg/L (in sample E). The desirable criterion for the concentration of ammonia in water is 0 mg/L [17-19]. This implies that the water samples are polluted when the concentration of ammonia is compared with the desirable criteria. However, the values obtained for the concentration in the entire water sample are below the permissible criteria. Source of ammonia-polluted water include domestic waste, decomposition of nitrogenous compound, industrial effluents and cement mortar pipe lining [11]. Ammonia can compromise disinfection efficiency, result in nitrite formation in the distribution system, can cause the failures of filters for the removal of manganese and cause taste and odour problems [20].

The bacteria species tested in the water samples were E-coli, faecal streptococci, clostridium perfringens and total coliform. These microorganisms were not found in the water samples hence there is no evidence of faecial contamination in the water samples [21].

4. Conclusions

The study shows that the conductivities of sample B and E were above the WHO standard. The concentrations of ammonia, nitrite and nitrate in all the water samples were below the permissible criteria but above desirable criteria. The ab-

sence of undesirable bacteria in the water was also confirmed. The bacteriological quality of all the water samples is therefore satisfactory for human consumption. Other analytical parameters were within the acceptance limit. It therefore follows that the major problem facing the production of sachet water manufactured in Akwa Ibom State is ammonia, nitrate and nitrite contamination. Therefore, the manufacturers of packaged water should embark on routine chemical and microbial analysis before the water is packed and distributed to end-users. Adoption of modified production methods and the use of control chart should be properly implemented. The use of nano filter has proven to be one of the best methods that can be used to purified water and is strongly recommended for implementation in the respective company production line. It is highly necessary that all the companies engaged in the business of water production and purification should have a standard laboratory in order to aid routine sample analysis.

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