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Original Research Article

Physicochemical Analysis of Some Sachet Water Samples Collected and Examined In Six Local Governments of Kano Metropolis, Kano State, Nigeria

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Abstract

The growing demands for adequate quality water resources create an urgent need to link research with improved water management, better monitoring, assessment, and forecasting of water resources and sanitation issues with much emphasis on the roles of stakeholders[13]. It must however be emphasized that adequate water quality needs seem to have improved greatly in some regions and countries especially in the developed world but for poor nations this is still a major issue (Stockholm International Water Institute, 2019). Among the key parameters listed by WHO[11] for the determination of water quality for domestic use are Conductivity, dissolved oxygen (DO), pH, color of water, taste and odor, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), nutrients (fertilizers), dissolved metals and metalloids (lead, mercury, arsenic, zinc, iron, copper, etc.) and dissolved organic substances. Most parameters tested for sachet water were found to be within permissible limits, which showed an excellent water qualities with the exception of Zinc which was analyzed with highest value of 0.04mg/l in samples collected from Fagge, Gwale, Municipal, Nassarawa and Tarauni which are all above the WHO permissible limit while Dala was 0.03 mg/l which is within WHO permissible limit. This study recommends the need for government, communities, private and individual to work collectively in public enlightenment/awareness on the medical risk of unsatisfied water quality consumption. Proper setting of water sources for public consumption, treatment and maintaining the existing water supply facilities is of great importance toward reducing and eliminating health threats as well as improve public health.

Keywords: Physicochemical Analysis, Physicochemical Parameters, water samples

INTRODCTION

The quality of any body of surface or ground water is a function of either or both natural influences and human activities. Without human influences, water quality would be determined by the weathering of bedrock minerals, atmospheric processes of evapotranspiration, and the deposition of dust and salt by wind. Others include, the natural leaching of organic matter and nutrients from soil, hydrological factors that lead to runoff, and by biological processes within the aquatic environment that can alter the physical and chemical composition of water[9]. Water quality assessment is a very complex subject, in part because water is a complex medium intrinsically tied to the ecology of the planet [9]. Among the key parameters listed by WHO[10] for the determination of water quality for domestic use are Conductivity, dissolved oxygen (DO), pH, color of water, taste and odor, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), nutrients (fertilizers), dissolved metals and metalloids (lead, mercury, arsenic, zinc, iron, copper, etc.) and dissolved organic substances. The world health organization says that every year more than 3.4 million people die as a result of water related diseases, making it the leading cause of disease and death WHO[12]. The problems also prevent millions of people from leading healthy lives, and undermine developmental efforts by burdening the society with substantial socio-economic costs for treatment of water-borne diseases. This problem is of great significance in cities in developing countries, where polluted water, water shortages, and unsanitary living conditions prevail.

MATERIALS AND METHODS

Study Area

Meteorologically, Kano metropolis is hot in most time of the year which makes sachet water business very lucrative. Kano is a region located between Latitude 10'03 north and between Longitude 7'10 East and 10'28 East in Northern Nigeria. Kano metropolis with about 9.4 million inhabitants[4] comprises of six local government areas namely: Dala, Fagge, Gwale, Municipal, Nassarawa and Tarauni. Sachet water is lucratively marketable in Kano metropolis because Kano is hot in most time of the year especially now that there is good competition in terms of quality and quantity between and among the sachet water packaging factories.

Sample Collection

The samples were collected from Dala local government and Tarauni local government. Sixty different sachet water brands were collected from each of the Local Government. Three of every 20 of sachet water of a particular brand and bags were sampled randomly for chemical and physical analysis as described by Sodhani[7].

Sample Size

Yamane[8] provides a simplified formula to calculate sample size. Sample size can be collected equally, proportionally or by key collection, equal sample collection was employed. This formula is used to calculate the sample sizes in scientific researches. A 95% confidence level and P = 0.5 are assumed for the formula.

$$n = \frac{N}{1 + N * e^2}$$

Where n is the sample size, N is the population size, and e is the level of precision.

$$n = \frac{3600}{1 + 3600 * 0.05^2}$$

n = 360

Physicochemical Analysis

In this research, the procedure used in determination of the level of concentration of the physicochemical parameters such as pH, total hardness, conductivity, calcium, magnesium, turbidity, copper, manganese zinc, lead and iron in various sachet water (pure water) samples collected was achieved by collecting water samples from various points and conducting laboratory analysis using some laboratory devices/meters. pH, Conductivity, Turbidity, Calcium and Chloride concentration were determined using electrometric method[1]. Total Hardness, was analysed using EDTA-Titrimetry method [1].

Heavy metals

Heavy metals like copper, lead, iron, zinc and manganese were all analyzed from the sachet water samples collected by using atomic absorption spectrophotometer [1].

Determination of copper in water samples

Copper was determined in the water samples by taken 100ml of water sample and digest with 5.0ml of concentrated nitric acid, after mixing with 5.0ml of nitric acid, it is then heated on a hot plate at temperature of 180^{0}C until it reduced from 100ml to 20ml of water sample, and allow to cooled for some times. Deionized water was then added to make up the volume to 100ml. and then the reading was recorded using atomic absorption spectrophotometer [1].

Determination of lead in water samples

The lead was digested with 5.0ml of concentrated nitric acid to 100ml of water samples and then heated on a hot plate at temperature of 180^{0}C until it reduced from 100ml to 20ml of water sample, and allow to cooled for some times. Deionized water was then added to make up the volume to 100ml. The reading was recorded using atomic absorption spectrophotometer [1].

Determination of iron in water samples

Iron was determined in the water samples by taken 100ml of water sample and digest with 5.0ml of concentrated nitric acid, after mixing with 5.0ml of nitric acid, it is then heated to temperature of 180^{0}C until it reduced from 100ml to 20ml of water sample, and allow to cooled for some times. To make it 100ml, 80ml of Deionized water was then added and then the reading was recorded using atomic absorption spectrophotometer[1].

Determination of zinc and manganese in water samples

In determination of zinc and manganese in pure water sample, the same procedure applied to determined copper, lead and iron in water sample was also used here. The zinc was digested with 5.0ml of concentrated nitric acid to 100ml op water samples and then heated on a hot plate at temperature of 180^{0}C until it reduced from 100ml to 20ml of water sample, and allow to cooled for some times. Deionized water was then added to make up the volume to 100ml. The reading was recorded using atomic absorption spectrophotometer atomic absorption spectrophotometer [1].

Table-1: Analytical methods adopted for physicochemical analysis

No	Parameter	Instrument used and method
1	pH	Digital pH meter [1]
2	Turbidity	Nephelometric Method [1]
3	Conductivity	Digital conductivity meter [1]
4	Calcium	Flame Photometric [1]
5	Magnesium	Spectrophotometry [1]
6	Total Hardness	EDTA-Titrimetric [1]
7	Chlorides	Mohr's Titrimetric [1]
8	Manganese	Spectrophotometry [1]
9	Copper	Spectrophotometry [1]
10	Iron (Fe)	Spectrophotometry [1]
11	Lead	Spectrophotometry [1]
12	Zinc	Spectrophotometry [1]

Analytical methods adopted for physicochemical analysis

Mean Concentration of Physicochemical Parameters for Sachet Water from Dala, Fagge, Gwale, Municipal, Nassarawa and Tarauni, Kano Metropolis

Mean Concentration of Physicochemical Parameters for Sachet Water in Dala, Fagge, Gwale, Municipal, Nassarawa and Tarauni, Kano Metropolis. The result for Physicochemical Parameters of sachet water sampled and assessed in Kano Metropolis presented pH; the highest value was from Municipal, Nassarawa and Tarauni 7.43 > 7.37 from Dala > 7.33 from Fagge > and 7.05 from Gwale which is the lowest, all pH values were within WHO and SON threshold (6.5 to 8.5). Turbidity highest value was from Tarauni 0.90 > 0.71 from Dala > 0.68 from Gwale > 0.61 from Fagge and Nassarawa > 0.45 from Kano Municipal. Electric conductivity highest result were from Municipal 4.98 > 4.71 from Fagge > 4.69 from Tarauni > 4.60 from Dala > 4.33 wale > 0.52 from Nassarawa. Calcium in this research has the highest value of 3.89 from Gwale > 3.77 from Dala > 3.74 from Fagge > 3.64 from Nassarawa > 3.51 from Tarauni > 2.98 from Municipal. Magnesium was 1.00 from Dala > 0.91 from Tarauni > 0.90 from Nassarawa > 0.81 from Gwale > 0.80 from Fagge and Municipal.

Total hardness was 7.27 from Fagge > 7.14 from Municipal > 7.08 from Dala > 6.90 from Gwale > 6.89 from Tarauni > 0.73 from Nassarawa. Chloride 0.99 is the value in samples from Dala > 0.93 from Fagge > 0.84 from Gwale and Nassarawa > 0.81 from Municipal > 0.80 from Tarauni. Manganese and Copper are throughout 0.02 in all the samples assessed. Iron is was measured in Fagge, Gwale and Nassarawa with value 0.04 which is above the WHO permissible limit while Dala Municipal and Tarauni were 0.03 which is within WHO permissible limit. Lead was analyzed to be 0.00 throughout the samples examined and is within WHO permissible limit for drinking water quality. Zinc was analyzed with highest value of 0.04 in samples collected from Fagge, Gwale, Municipal, Nassarawa and Tarauni which are all above the WHO permissible limit while Dala was 0.03 which is within WHO permissible limit.

Table-2: Mean Concentration of Physicochemical Parameters for Sachet Water Dala, Fagge, Gwale, Municipal, Nassarawa and Tarauni, Kano Metropolis

	Kano Metropolis					
	Dala	Fagge	Gwale	Municipal	Nassarawa	Tarauni
pH	7.37	7.33	7.05	7.43	7.43	7.43
Turbidity (ntu)	0.71	0.61	0.68	0.45	0.61	0.90
Conductivity (µS/cm)	4.60	4.71	5.33	4.98	0.52	4.69
Calcium (mg/l)	3.77	3.74	3.89	2.98	3.64	3.51
Magnesium (mg/l)	1.00	0.80	0.81	0.80	0.90	0.91
Total hardness (mg/l)	7.08	7.27	6.90	7.14	0.73	6.89
Chlorides (mg/l)	0.99	0.93	0.84	0.81	0.84	0.80
Manganese (mg/l)	0.02	0.02	0.02	0.02	0.02	0.02
Copper (mg/l)	0.02	0.02	0.02	0.02	0.02	0.02
Iron (mg/l)	0.03	0.04	0.04	0.03	0.04	0.03
Lead (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00
Zinc (mg/l)	0.03	0.04	0.04	0.04	0.04	0.04

Two ways Anova showing differences in concentration between Local Government and physicochemical parameters in the water samples

The two ways ANOVA in table 9 above reveals that the difference in mean concentration of Physiochemical parameters for sachet water is insignificant between the six local governments under study; this is because the P-value (0.091) is greater than the specified α-value of 0.05. But however, further analysis using Duncan test was employed to assess the mean concentration and is shown in table 9 above. it shows that Nassarawa LG has the least mean concentration compared to the other five LG while Gwale and Dala has the highest mean concentration of physiochemical parameters for sachet water.

Table-3: Two ways Anova showing differences in concentration between Local Government and physicochemical parameters in the water samples

Tests of Between-Subjects Effects					
Source	Sum of Squares	Df	Mean Square	F	Sig.
Model	738.862[a]	17	43.462	56.182	.000
LGA	7.777	5	1.555	2.011	.091
PCP	453.077	11	41.189	53.243	.000
Error	42.548	55	.774		
Total	781.410	72			
a. R Squared = .946 (Adjusted R Squared = .929)					

Keys:
Df: degree of difference
F: frequency
Sig: Significance
LGA: local government area
PCP: physicochemical parameters

Duncan multiple range tests between physicochemical parameter among the water samples.

Duncan multiple range tests presented result in table 10 between physicochemical parameters among the water samples. Furthermore, the ANOVA table shows that there is significant difference between the Physiochemical Parameters (PCP) because their collective P-value (0.000) is very negligible compared to the specified α-value of 0.05. Thus, Duncan test as a further analysis was used to spell out the differences clearly and base on the Duncan result in Table 4.9, we observed that PCP was grouped into four strata such that within strata there is insignificant difference and between strata there is significant difference. However, PH has the highest mean concentration followed by Total Hardness (TH) and the least was Lead (Pb).

Table-4: Shows Duncan multiple ranges test between physicochemical parameter among the water samples.

Duncan[a,b]					
PCP	N	Strata			
		1	2	3	4
Pb	6	.0000			
Mn	6	.0200			
Cu	6	.0200			
Fe	6	.0350			
Zn	6	.0383			
Turb	6	.6600			
Cl	6	.8683			
Mg	6	.8700			
Ca	6		3.5883		
EC	6		4.1383		
TH	6			6.0017	
pH	6				7.3400
Sig.		.150	.283	1.000	1.000
b. Alpha = 0.05.					

Keys:
Pb: lead
Mn: manganese
Cu: copper
Fe: iron
Zn: zinc
Turb: turbidity
Cl: chlorine
Mg: magnesium
Ca: calcium
EC: electric conductivity
TH: total hardness

The Principle Component Analysis (PCA)
The Principle Component Analysis categorized the both dependent and independent variables in to seven iterations and presented as follows;
Component 1 (C1) accounts for copper, calcium, magnesium and manganese with values of 0.790, 0.691, 0366 and 0.610 respectively.
Component 2 (C2) accounts for lead only with value of 0.647
Component 3 (C3) accounts for zinc with value of 0.834 and iron with value of 0.687.
Component 4 (C4) accounts for chloride with value of 0.864 and bacterial load (Coliform per unit). This iteration is very interesting one just because of the opposite relation between the dependent variable (CFU) and only one independent variable (chloride). This is because more concentration of chloride in Water the less bacterial loads and vice versa.
Component 5 (C5) accounts for Electrical Conductivity with value of 0.925.
Component 6 (C6) accounts for pH with value of 0.904.
Component 7 (C7) accounts for turbidity with value of 0.875.

Table-5: Principle Component Analysis/ Rotated Component Matrix showing linkage between the main variables that affected the normal state of sachet water in Kano Metropolis

	Component						
	1	2	3	4	5	6	7
Copper	0.790	0.045	-0.008	0.162	0.051	-0.125	0.251
Calcium	0.691	-0.067	-0.375	0.059	0.076	-0.094	0.021
Magnesium.	0.636	0.108	0.108	-0.259	-0.264	-0.249	0.104
Manganese	0.610	-0.250	0.121	0.191	0.081	0.201	0.253
Total hardness	0.006	-0.827	-0.090	-0.091	-0.246	0.085	-0.031
Lead	-0.054	0.647	0.199	-0.079	-0.239	-0.049	0.297
Zinc	0.072	0.012	0.834	0.012	0.055	0.144	-0.113
Iron	-0.157	0.128	0.687	-0.049	0.007	-0.367	0.062
Chloride	0.002	-0.002	-0.140	0.864	0.074	-0.020	-0.026
CFU	-0.216	0.092	0.317	0.630	-0.364	-0.131	0.103
Electric Conductivity	-0.077	0.031	0.070	-0.040	0.925	-0.025	-0.022
pH	-0.005	0.024	-0.027	-0.082	-0.013	0.904	0.065
Turbidity	-0.008	-0.007	-0.082	0.014	-0.035	0.023	0.875
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							

The correlation between one independent variable with another set of other independent variables

Chloride was the first independent variable which showed slight relationship with pH at 0.03 and turbidity at 0.012. Turbidity correlated with electrical conductivity at 0.093, calcium at 0.056, Magnesium at 0.073, Manganese at 0.069

and copper at 0.098. Electrical conductivity correlated with calcium at 0.032, magnesium at 0.039 and manganese at 0.051 and zinc at 0.067. Calcium was strongly related with magnesium at 0.078, manganese at 0.041 and total hardness at 0.042. Magnesium was related strongly with iron at 0.085. Iron correlated with zinc at 0.095 and this is also a strong correlation. Lead correlated with total hardness at 0.068 and finally Zinc correlated with total hardness at 0.045

Table-6: Correlation between one independent variable with another set of other independent variables

	Chloride	pH	Turb	EC	Cal.	Mag.	Mang	Cu	Fe	Pb	Zn	T/Hardness
Chloride	1											
pH	0.03*	1										
Turb	0.012	0.058*	1									
E. C.	0.002	-0.004	0.093**	1								
Cal.	0.025	-0.043	0.056*	0.032*	1							
Mag.	0.048*	0.061**	0.073**	0.039*	0.078**	1						
Mang.	-0.11	-0.08	0.069**	0.051**	0.041*	0.196	1					
Copper	0.143	-0.088	0.098**	0.101	-0.031	-0.291	-0.04	1				
Iron	-0.05	-0.186	-0.018	0.019	-0.076	-0.136	0.085**	0.152	1			
Lead	-0.1	-0.026	0.039	-0.113	-0.147	-0.04	0.127	0.196	0.169	1		
Zinc	-0.1	-0.018	-0.041	0.067**	-0.159	0.023	-0.065	0.333*	0.095*	0.023		1
T/Hdnss	-0.04	0.043	-0.003	-0.157	0.042*	0.03*	0.013	-0.014	-0.211	0.068*	0.045*	1

* Correlation is significant at the 0.05 level.
≥ Correlation is very strong
< Correlation is very weak

Discussion

In the present research, table 2 showed the physicochemical results from the samples collected and examined presented that the pH values of samples from area A to F (Dala, Fagge, Gwale Municipal, Nassarawa and Tarauni) ranges from lowest to highest 7.05(Gwale), 7.33(Fagge), 7.37(Dala), 7.43(Municipal), 7.43 (Tarauni) and 7.43(Nassarawa). The pH was within the standard limit of 6.5 to 8.5 as stipulated by[12]., as criteria for drinking water. This also conforms to the pH range reported by[6]. According to Mead[3], the PH of most natural waters range from 6.5 to 8.5. The pH of water was extremely important; fluctuation in optimum pH ranges may lead to an increase or decrease in the toxicity of poisons in water[6]. Turbidity ranged from 0.45-0.90 NTU in samples obtained from site A-F to 2.23±0.32 NTU in samples obtained from site B. Manganese values ranges from 0.15mg/l to 0.24mg/l, Calcium, Magnesium, total hardness concentrations falls below WHO standards for drinking water quality as presented in Table 3 (Two ways Anova). Table 4, Duncan multiple range tests showed that Nassarawa local government has the least concentration compared to the other five local governments while Gwale and Dala has the highest concentration of physicochemical parameters for sachet water. Table 5 further explained whether there were relationships among and between the sample sites in physicochemical concentrations in the samples. this shown that the mean of total hardness, Ca^{2+} Hardness Mg^{2+} Hardness, Manganese, iron and Cu^{2+} were not significantly different ($P>0.05$) for all the samples while that of pH shows a significant ($p<0.05$) difference between the samples. Total hardness in the other hand ranged from 85.00±0.03 mg/l in samples obtained from site A to 103.00±0.20 mg/l in samples obtained from site C. Electrical Conductivity ranged from176±0.02µS/cm in samples obtained from site D to 282±0.25µS/cm in samples obtained from site B. there were significant difference between physicochemical parameters (PCP) because their collective p-values (0.000) was very small as compared with α-value of 0.05. This further categorized the both dependent and independent variables in to seven (7) iterations in relation between the dependent and independent variable examined in various water samples. Copper, calcium, magnesium manganese were grouped in first iteration, lead in the second iteration, zinc and iron in the third iteration, in the fourth iteration chlorine and bacterial load were grouped together, electrical conductivity is the only parameter in the fifth iteration, pH in the sixth iteration and finally turbidity in the seventh iteration. Table 6 explained the linkages between one variable with another or set of other independent variables were presented in relation to seven iteration as; copper, calcium, magnesium and manganese were linked in first iteration, lead in second iteration, zinc and iron in third iteration, chloride and colony forming units in fourth iteration, electric conductivity in fifth iteration, pH in sixth iteration and turbidity in eighth iteration. The values obtained were below the WHO maximum permissible limits and correlated as; chloride was correlated to pH and turbidity, turbidity was correlated to electric conductivity, magnesium, manganese and copper, electric conductivity correlated with calcium, magnesium, manganese and zinc, calcium was strongly correlated with magnesium, manganese and total hardness, magnesium was strongly related to iron, iron was correlated with zinc, lead was correlated with total hardness and finally zinc was correlated with total hardness. Accordingly, all the water samples from each of the sampling sites were colorless and odorless which were in line with WHO standards[10]. It could therefore be argued that physically, the sachets water conformed to the recommended standards for potable water. An indication that the sachets water depots were not polluted in terms of the chemical parameters. Nevertheless, the values of all the chemical parameters investigated in this study were below the WHO permissible limits.

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