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ASSESSMENT OF PHYSICO-CHEMICAL CHARACTERISTICS OF SELECTED BRANDS OF PACKAGED TABLE WATER IN KANO METROPOLIS, NIGERIA

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ABSTRACT

This research work was a descriptive type and aimed at evaluating the quality of packaged table water produced within Kano metropolis, Kano state Nigeria. Packaged (Sachet) drinking water commonly referred to as pure water is widely consumed and accepted. The physical and chemical qualities of twenty-two brands of packaged table water sold within Kano Metropolis were Sampled and evaluated to ascertain their compliance with recommended standards set by World Health Organization (WHO).Standard Laboratory procedure were used for the analysis. Physical parameters were determined by instrument methods and heavy metals content were assessed using atomic absorption spectrophotometer (AAS).The results indicate significant variation in heavy metal concentration across different samples, For Lead (Pb), the highest mean values were seen in samples W3(0.0994mg/l), W8 (0.0992mg/l)and W10 (0.1967mg/l) while absence of Chromium (Cr) and cadmium where noticed in samples W8, W12, W22 and W3, W9, W21 respectively.Elevated levels of Cadmium were seen in W18(0.1002µg/l.) All Labeling requirements were found to be adequate except for batch coding (Batch number, Manufacturing date, & Expiration date) which is a major requirement in good manufacturing practice.Manufacturers need to regularly check the efficiency and effectiveness of their filtration setup (reverse osmosis machine) and government agencies need to step up routine monitoring to ensure compliance with manufacturing standards.

Keywords:*Physicochemical Parameters, PackagedTable Water, Heavy metals. Kano Metropolis*

1.0 INTRODUCTION

Water is a basic requirement for life and it is considered to be portable if it isodourless, colourless, tasteless and free from biological pollutant. (Omalu *et al. 2010).* An adult weighing 53-63kg requires approximately three (3) liters of water every day to preserve a healthy living (Onweluzo and Akuagbazie. 2010). In Nigeria water deliverywaslooseduring the colonial era however the country has now transformed to a capitalist financial system, so portable water attracts fee and charges in manytowns and cities. (Edema *et al. 2011).* Negligence by Nigerian authorities and inadequatefunding in public infrastructure has left the publicto consume water in an unclean state. *(Dada, 2009).* The increased demand for portable drinking water is attributed to lack of safe municipal water in urban areas and the safety and ready to use packaged water becomes sacrosanct as it meets the demand of healthy lifestyle. (Oyedeji *et al. 2010 and* Airaodion *et al. 2019)*. Several research on the quality of packaged water reveals that international quality requirements have been compromised. (Oyedeji *et al. 2010).* The wholesomeness of water is of vital importance for human beings since it is vital for human health. (Rabiu *et al. 2018*). The quality of ground or surface water depends on various chemical constituents and their concentration. (Yahaya *et al. 2017).* Regulation of water by the help of prepacked food, water, and ice labelling regulation 2019 by NAFDAC gave a clear and concise process on how this can be achieved. *(*NAFDAC, 2019*).*About 18% of urban households in Nigeria uses packaged water as the primary source of drinking water and there is need for improved regulatory oversight with more stringent regulatory measures. (Arit *et al. 2021)*. Heavy metal traces can be discovered in water sources and because their toxicity levels vary on the organisms to which they are exposed, they can pose major health risks to both humans and the ecosystem. (Masindi and Muedi *2018*). The industrial activities in Kano pose a lot of threat to river water and hence they must adhere to environmental regulatory policies. (Shawai *et al.2019*)**.**Many research showed Metals such as iron, calcium, chromium, and aluminum have been detected in surface water (Titilawo *et al*.2018**)** and also in sachet water **(**Emenike *et al.* ***2018***). In ground water cadmium, lead, manganese, and nickel has equally been identified above permissible levels for drinking water. (Ayedun *et al. 2015*). Ground water can equally contain light polycyclic aromatic hydrocarbons and flourides above permissible levels as shown in many reports in various regions across Nigeria. (Adekunle *et al., 2017 and* Emenike *et al. 2018*). Packaged water produced within Owerri Imo state has high levels of cadmium and nickel above the permissible limits however a lot of manufacturing outfit do comply with the safety and regulatory standards. (Onyeneke *et al. 2020).* Storage conditions are very vital for finished product both in the warehouse and retail shops. (Halage *et al. 2015)*

The aim of the research is to evaluate the physio-chemical characteristic of packaged water sold within Kano metropolis.

The following research question were asked

- Are packaged table water sold within Kano metropolis free from heavy metals (lead, Chromium, cadmium)?
- Are packaged table water sold within kano metropolis safe for consumption?

  The following Hypothesis were tested

  1. H^1 o: Packaged water sold within the metropolis are safe and free from contaminants.
  2. H^2 o: Packaged water sold within the metropolis may contain harmful contaminants.

2.0 MATERIALS AND METHODS

2.1 Description of the Study Area

Kano metropolis is located between Latitudes 11° 56' N to 12° 04' N and Longitudes 08° 26' E to 08° 39' E (Figure 1). The climate of the area is the tropical wet and dry type with wet season lasting for 4 - 5 months between May and September (Olofin and Tanko, *2002*). The relief is about 472m above sea level on the northern high plains. Its 2006 population census was approximately 2,163,225 in the city and 2,828,861 in the metropolis, while the current projected population of 2015 is 3,876,273 with a growth rate of 3.5% per annum (**NPC, 2015**).

Map of the Study area

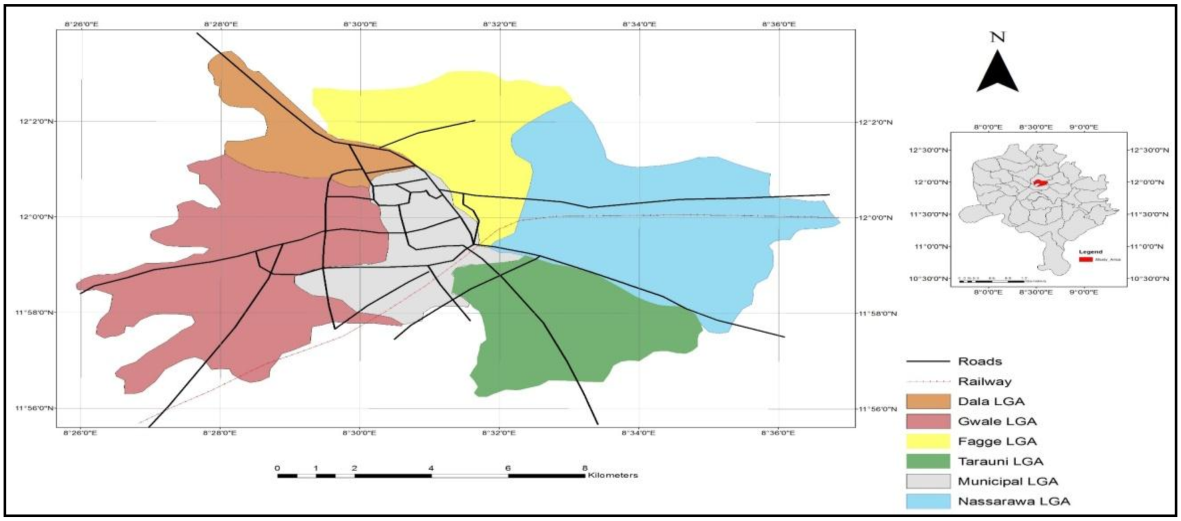

Figure 1. Kano Metropolis

Source: Adapted from the Administrative Map of Kano State.

2.2 Sample Collection

All the samples were purchased from water vendors within Kano metropolis and labeled W1 to W22 in triplicate. A sample size of eighty (80) NAFDAC registered package table water were purchased within the metropolis using simple random sampling, Excel spreadsheet was used togenerate simple random sampling sequence from the sampling frame.(Muhammad, *2017 &* Najib, *2015*). Twentytwo (22) samples of the packaged water were purchased frompackaged table water vendors with same batch number in triplicates. The Samples were labeled/ coded and placed in a clean non greasy polyethylene bag. The samples were then carried to the Laboratory for analysis.

2.3 Water Analysis

All the glassware used were washed with distilled water and sterilized in an autoclave at 121^{o}C for 15 minutes. The sachet water were physically examined and the product name, manufacturers address, batch number, NAFDAC registration number, manufacturing and expiry dates were recorded as described by*(*Oyeku *et al. 2001;* Airaodion *et al.2019*).

2.4 Physio-Chemical Properties of Water

2.4.1 Determination of pH

The pH was first calibrated with buffer solution of pH 7.0 and 4.0. The sample was carefully transferred into a clean beaker and the pH electrode was immersed in the water sample and the measurement was read as appeared on the screen of the machine. The pH electrode was then wiped with clean tissue paper and rinsed with distilled water (Sharma *et al. 2017*).

2.4.2 Determination of Conductivity

Potassium chloride standard solution was placed in a 50 ml beaker and the conductivity cell was suspended in the solution, holding it approximately 7.5 cm above the bottom of the beaker. The readings of the conductivity were then adjusted to 100 µS/ cm. The conductivity cell was then rinsed with distilled water and then the measurement of each sample was read on the screen. (Sharma, *2017*).

2.4.3 Determination of Total Hardness

Using a measuring cylinder 50 ml of water sample was measured and transferred into 250 ml conical flask. 1 ml of ammonia buffer was added and a pinch of indicator (Eriochrome black T) was equally added. The sample was mixed thoroughly and thereafter titrated with standard Ethylene diamine tetra acetic acid (EDTA) until there was a colour change from pink to blue (De Zuane, 1996). Total hardness was then calculated using the formula: Mg CaCO3/e = 1000∗10∗Vt∗M Vs Where Vt is the amount of titrant needed to reach the end point in ml, M in mg of CaCO3 equivalent to 1ml of EDTA titrant and Vs is the volume of sample analyzed in ml. (Sharma *,2011*).

2.4.4 Determination of Total Alkalinity

Using a 50 ml measuring cylinder, 50 ml of water sample was measured and transferred into a 250 ml conical flask. The pH of the water sample was measured in other to ascertain which indicator is to be use; methyl orange was used as indicator. Three (3) drops of methyl orange indicator was added to the sample and mixed thoroughly to give an orange color. The sample was then titrated against 0.05 m H_2S0_4 until the color change to pink; the volume of the titrant was then recorded. Total alkalinity from the titration was calculated using Alkalinity ($MgCaCO_3L$ -1) = 1000∗Vt∗M V Where Vt is the total volume in ml of the acid standard used, M is the mass in (mg) of CaCO3 in (mg) of $CaCO_3$ equivalent to 1 ml of titrant (500mgml-1 for 0.05 m H_2SO_4) and Vs = volume of sample (ml). (*APHA, 1992).*

2.4.5 Determination of Temperature

The temperature of the sample was determined using a thermometer (-10 – 110 ^{oC}) range (Gh zeal ltd-London-England). The thermometer was dipped in a 50 ml beaker containing the sample for about 5 minute to allow for equilibrium before taking the readings.(Dinrifo *et al.* 2010).

2.4.6 Determination of Total Dissolve Solid (TDS)

Total Hardness was determined by titrimetric method using ethylenediamine tetra acetic acid (EDTA) as described by APHA (1998). 50ml of each water sample was measured in a 250ml conical flask and mixed with 1ml of NH4Cl – NH4OH buffer; small amount of Eriochrome Black T indicator was added and titrate with 1M EDTA to a blue end point.Total hardness was calculated with the expression:

$$\text{Total hardness (mg/L)} = \frac{A \times N \times 1000}{50\text{ml}}$$

Where A = Titre value, and N is the Normality of EDTA

2.4.7 Determination of Nitrite

This was done using a potable UV-visible spectrophotometer (HACH D 89). Two cuvettes were filled with 10 cm3 of the water sample and the content of nitraver 5 nitrate reagent powder pillow was added in one cell, It was stoppered and shaken vigorously for one (1) minute, after which it was allowed to stand for five minutes. Nitraver 3 reagent powder was added and allowed to stand for 5 minutes; A pink colourappearance is an indication of positive nitrite. Absorbance is expressed in mg/l and was then measured.(AOAC, 2006).

2.4.8 Determination of CO_2

50 ml of water sample was taken in a conical flask. 2 – 3 drops of phenolphthalein indicator was then added. If the solution colour turns pink, it is an indication that CO2 is absent, but if the solution is colourless, it indicates that CO2 is present. The water samples were titrated against 0.045 N Na2CO2 until a light pink colour developed. Then volume of titrant used for titration was noted. Titration process was repeated for another two times. The readings ofthe tritant volume for each water sample were recorded as follows:

Calculations:-

DCO2 = Volume of titrant used

X 1000

Volume of sample taken for titration

= mg/l

Report the value to the nearest of first decimal i.e. 0.1 mg/l

2.5 Determination of Heavy metal Content of the Samples

Atomic absorption spectrophotometer (AAS) AA 6800 series shimazocorp was used for the determination of heavy metals.

2.5.1 Principle of the procedure

The atomic absorption spectrometry uses absorption of light of intrinsic wavelengths by atoms. All atoms are classified into those having low energies and those having high energies. The state having low energies is called the ground state and the state having high energies is called the excited state. The atom in the ground state absorbs external energies and is put in the excited state. (AOAC, 2010).

2.5.2 Procedure

Ten milliliters of the samples were directly transferred to the sample container and aspirated to the AAS; reading was recorded in ppm (AOAC, 2010).

The appropriate lamps and correct wavelength for each element is specified in the instruction manual.

2.6 Statistical Analysis

The variance of the heavy meals were statistically analyzed using SPSS software version 2016 developed by Microsoft Inc.

3.0 RESULTS AND DISCUSSION

3.1 Results

The bar chart below presented comprehensive data on the concentration levels of all samples. Lead (Pb) showed its highest mean values at 0.10 mg/L in samples W3, W8, and W10, whereas the lowest means, measuring 0.01 mg/L, were observed in samples W5, W15, W20, and W22. Except for water samples from locations W8, W12, and W22, which showed no traces of Chromium (Cr), all samples revealed a range of chromium concentrations from 0.01 mg/L in W9, W11, and W18 to 0.04 mg/L in W1 and W17, all falling within the WHO standard of 0.05 mg/l. Notably, water samples labelledW3, W9, and W21 exhibited no presence of Cadmium (Cd), while all other samples investigated for cadmium evaluation exceeded the WHO-prescribed limit of 0.003 mg/L, with location W18 recording the highest value of 0.1 mg/L (Figure 4.1). Table 1 shows labeling requirements which all conforms to the acceptable guidelines with the exception of batch coding. Table 2 shows the physicochemical parameters and Table 3 shows the heavy metal content.

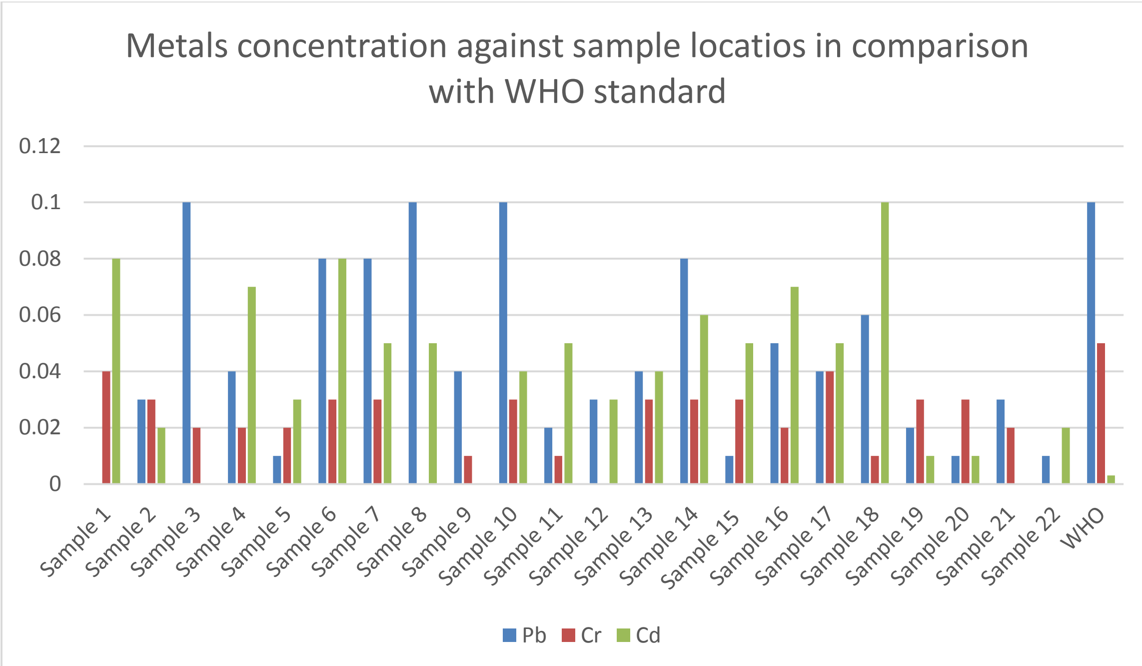

Figure 1:

Concentrations of heavy metals against different samples

Table I: Labeling requirement for package water

S/N	CODE	REG	VOLUME	BATCH CODING	ADDRESS	PRECAUTION	DISPOSAL SYMBOL
1	W1	+	+	-	+	+	+
2	W2	+	+	-	+	+	+
3	W3	+	+	-	+	+	+
4	W4	+	+	-	+	+	+
5	W5	+	+	-	+	+	+
6	W6	+	+	-	+	+	+
7	W7	+	+	-	+	+	+
8	W8	+	+	-	+	+	+
9	W9	+	+	-	+	+	+
10	W10	+	+	-	+	+	+
11	W11	+	+	-	+	+	+
12	W12	+	+	-	+	+	+
13	W13	+	+	-	+	+	+
14	W14	+	+	-	+	+	+
15	W15	+	+	-	+	+	+
16	W16	+	+	-	+	+	+
17	W17	+	+	-	+	+	+
18	W18	+	+	-	+	+	+
19	W19	+	+	-	+	+	+
20	W20	+	+	-	+	+	+
21	W21	+	+	-	+	+	+
22	W22	+	+	-	+	+	+

+= Present - = Absent

Table 2: Physicochemical parameters of package table water.

S/N	CODE	PH	CO_2	TA	TH	TDS	NO_2
1	W1	6.86	6	23	32	40	0.003
2	W2	6.51	4	13	NIL	20	NIL
3	W3	6.76	3	12	9	20	0.08
4	W4	7.03	2	16	8	20	NIL
5	W5	6.81	6	9	30	30	0.28
6	W6	7.58	2	13	NIL	10	NIL
7	W7	7.01	2	26	7	30	NIL
8	W8	6.83	1	12	16	30	0.24
9	W9	6.97	4	13	31	30	0.10
10	W10	7.49	2	9	8	20	NIL
11	W11	7.03	3	7	10	30	NIL
12	W12	8.38	4	25	21	40	NIL
13	W13	7.60	12	10	55	50	0.012
14	W14	7.13	4	8	40	50	NIL
15	W15	7.42	8	14	17	30	NIL
16	W16	7.13	9	17	13	30	0.12
17	W17	7.16	21	44	34	50	0.16
18	W18	6.58	7	8	11	40	NIL
19	W19	7.18	14	42	54	90	NIL
20	W20	6.62	3	6	12	20	NIL
21	W21	6.66	7	24	18	20	0.15
22	W22	6.77	10	7	0	20	NIL
WHO Limits (2011)		6.8-9.0	50mg/l	100	100-200	500	0.2mg/l

Table 3: Heavy Metals concentration in package water:

S/N	CODE	Pb	Cr	Cd
1	W1	-	0.0376	0.0843
2	W2	0.0285	0.0283	0.0193
3	W3	0.0994	0.0234	-
4	W4	0.0384	0.0192	0.0678
5	W5	0.0111	0.0243	0.0288
6	W6	0.0827	0.0273	0.0765
7	W7	0.0830	0.0293	0.0527
8	W8	0.0992	-	0.0522
9	W9	0.0364	0.0122	-
10	W10	0.1967	0.0298	0.0364
11	W11	0.0166	0.0121	0.0494
12	W12	0.0337	-	0.0337
13	W13	0.0364	0.0337	0.0361
14	W14	0.0754	0.0326	0.0622
15	W15	0.0116	0.0316	0.0455
16	W16	0.0544	0.0236	0.0721
17	W17	0.0447	0.0437	0.0504
18	W18	0.0485	0.0116	0.1002
19	W19	0.0226	0.0277	0.0141
20	W20	0.0102	0.0256	0.0131
21	W21	0.0331	0.0186	-
22	W22	0.0110	-	0.0248
WHO LIMITS		0.1mg/l	0.05mg/l	0.003µg/l

3.2 Discussion

3.2.1 Heavy Metals Concentration

The results indicate significant variations in heavy metal concentrations across different samples. For Lead (Pb), the highest mean values in samples W3 (0.0994mg/l), W8 (0.0992mg/l), and W10 (0.1967mg/l) agrees with study conducted by Kopdorah *et al. (2023*) on sachet water which showed higher concentration of lead, cadmium and arsenic above the WHO acceptable limit. This however could be attributed to industrial activities, urban runoff, or other sources of pollution in those areas. Conversely, the lowest mean values in samples W5(0.0111mg/l), W11(0.0166mg/l), W15(0.0116mg/l), W20(0.0102mg/l), and W22(0.0110mg/l) suggest a comparatively lower impact of such pollutants in those locations, possibly due to better environmental practices or natural factors (Bello *et al., 2022 and* Ogunala *et al., 2015*).

The absence of Chromium (Cr) in samples from locations W8, W12, and W22 agrees with a similar research conducted by Akintelu *et al.(2021)* where they showed low values of heavy metals this however might be linked to the absence of specific industrial activities or geological factors that contribute to chromium presence in the other locations. The variation in chromium levels in other samples could be related to local industries, disposal practices, or geological formations (Abdullahi *et al., 2016 and* Bashir *et al., 2022).*Only slight variation was observed in sample W17 (0.0437mg/l) which is within the WHO acceptable limit of 0.05mg/l.

For Cadmium (Cd), locations W3, W9, and W21 showing no presence might indicate better pollution control measures or the absence of relevant industries. On the other hand, locations exceeding the WHO limit, particularly sampleW18 with the highest value (0,1002µg/l)which corresponds with Similar Studies by Sani *et al. (2021*) at Gombe where they showed high Percentage of heavy metals (Lead, Mercury, Cadmium and Arsenic) above WHO acceptable limits. Such locations or source of water may experience higher industrial discharges or improper waste disposal (Olusola *et al., 2017;* Oludairo . and Aiyedun, *2016).*

3.2.2 Physical Parameters

Physical parameters tested in all the Packaged water samples were colourless, odourless and tasteless, this can be attributed to the use of sand Filters, micro filters and activated carbon filtration processes used during production in all the sachet water companies, these are important quality parameters affecting acceptability of water for consumption (Yakasai *et al.2010*). All labeling requirements were found to be adequate as shown in table 1, however only batch coding were not visible in all the samples which is a major factor in good manufacturing practice. (NAFDAC, 2019).

3.2.3 pH

The pH of the sachet water ranged from 6.51-7.60 indicating acidic, neutral, and slightly alkaline. The pH values obtained showed that all the samples had pH within the WHO acceptable limits (6.5 to 8.5) which corresponds with similar research carried out at Ado Ekiti by Tawale *et al. (2022)*however other studies elsewhere by Ibe *et al.* (2022) in Owerri showed low pH levels which is not in agreement with the current study. Also other studies by Alhassan *et al.*(*2008*) and Sheshe&Magaji*(2014)* showed higher levels of pH within the range of 6.5 to 8.09 in Kano metropolis, also Mohamed and Murtala *(2015*) reported same in Kastina metropolis and Adiotomre and Agbale *(2015)* reported in Benin city, Edo State .

3.2.4 TDS

Total dissolved solids (TDS) of 10 to 90mg/l was recorded in the packaged water; all the values were within the acceptable limit of 500mg/l as stipulated by the NIS, 2007 and WHO, 2004 standards. Nwosu and Ogueke *(2004*) made a similar observation in sachet water sold in Lagos and Owerri Metropolis respectively. The taste of drinking water is adversely affected when total dissolved solids exceed 500 mg/l and may render the water unsafe for Consumption.

3.2.5 Total hardness

Total hardness in all the packaged water ranged between 7 to 55 mg/L, these values are within the acceptable limit of 150mg/L required by the NIS, 2007 and WHO, 2004 standards. Hard water helps form strong bones and teeth because of high calcium concentration and could also help reduce the dangers of heart diseases. The concentrations of total hardness of the packaged water in this study were similar to the result reported by Sunday *et al. (2016)* on the determination of shelf life of some sachet water in Ogbomoso, Oyo state Nigeria.

3.2.6 Nitrite

Nitrate concentrations were very low in all the brands of packaged water. It ranges from 0.003 to 0.28 mg/L, as presented in Table 2. The concentrations of nitrate in the water samples fell within WHO permissible standard of(50 mg/l) for drinking water *(WHO ,2008).* Intake of water with a high concentration of nitrate above the permissible standard was reported to cause health diseases in infants.

3.2.7 CO_2

All Carbon dioxide values werewithin the acceptable limits of the standards. The lowest value was seen in sample W8 with 1mg/l and the highest was seen in sample W17 with 21mg/l which were all within the acceptable limit of 50mg/l. Similar research was reported by Taiwo *et al.* (2012**)**in sachet water at Abeokuta, Ogun State, Nigeria. These values reported in these studies were in conformity with WHO standard.

4.1 Conclusion

In conclusion, the examination of heavy metal concentrations in water samples highlights diverse levels across various samples. While Lead (Pb) concentrations peaked in samples W3(0.0994mg/l), W8(0.0992mg/l), and W10(0.1967mg/l), Chromium (Cr) concentrations typically adhered to WHO standards except for samples W1(0.0376mg/l) and W17(0.0437mg/l) which were relatively higher but still within the acceptable limit. Conversely, Cadmium (Cd) concentrations surpassed WHO limits in many locations with sample W18 (0.1002µg/l) exhibiting the highest concentration. This emphasizes the imperative for focused initiatives to address and alleviate heightened cadmium levels in specific water sources, ensuring adherence to safety standards. The assessment of chemical and physical parameters such as appearance, colour, taste and pH all conformed to the acceptable standards.

4.2 Recommendations

Possible solutions include regular checking of the efficiency and effectiveness of filtration setups by manufacturers, regular routine monitoring by regulatory agencies, implementing stricter pollution control measures in areas with high concentrations, regulating industrial discharges, promoting sustainable practices and conducting further investigations into specific pollution sources. Collaborative efforts between industries, local authorities, and environmental agencies are crucial to address and mitigate these concerns effectively.

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