

Development of water quality map for Ogbomosho metropolis

Abstract

The quality of water is usually strongly considered as criteria for its suitability for a purpose. Important physical, chemical and bacteriological properties form the basis to judge the quality of water. To determine whether a particular water sample is of acceptable quality for drinking, it is necessary to compare its properties with the regulatory limits of certain well known and accepted standards set by organizations like World Health Organization, US Environmental Protection Agency, Nigeria International Standards etc. The focus of this project is to investigate the extent of contaminants in the available water sources and the causative agents in Ogbomosho North and South Metropolis. 100 water samples were collected through an evenly spread sample point positioning system across the study area, to give an averagely accurate analysis of the result. The Physical properties like Temperature, Turbidity, Total Dissolved Solids; Chemical parameters like Heavy metal concentration and Bacteriological parameters like E-Coli and T-Coli coli form count were analysed and the results were compared with regulatory limits. From the results derived, the physical parameters of tested water samples fall within the WHO standard limits.

However, water samples in Ogbomosho North and South Local Government Area contain E-Coli and T-Coli concentration that exceeds the WHO standard of 0 MPN/100ml. Wards like Ilogbo (Papa Abede) and Ilogbo/Arada were found to contain high concentration of Iron that exceeds the acceptable 1mg/l limit due to the presence of a number of dumpsites and light industries. Phosphate concentration in all water samples tested exceeded the WHO and NIS standard of 5mg/l, which is as a result of uncontrolled septic waste and fertilizer run-off.

The concentration of Manganese in all water samples across the study area also exceeded the 0.2 mg/l WHO and NIS standard for potable water as a result of the unchecked Industrial activities and vehicle emission in the area. Other areas with significant pollution cases especially Sulphate concentration that exceeds the WHO regulatory limit of 250mg/l in water samples include Osupa and Jagun, this can be attributed to the number of the dumping sites present and action of leachates in the areas. The resulting health implication of these findings was discussed. A water quality map was developed to show the varying concentration of water properties across Ogbomosho North and South Local Government Area. The study suggests waste control activities be adopted in the study area and public enlightenment schemes to protect water sources in the area, as the task of reducing the extent of contaminants in water sources in Ogbomosho North and South LGA requires the effort of the residents, government and relative organizations.

Keywords: potable water, contaminants, ogbomosho, north, south

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Introduction

Water is a vital resource in the ecosystem since it supports life of all living organisms. Though, it occupies about 70% of the earth's surface, yet a greater percentage of the world's population, most especially in developing countries live without access to safe water.¹ This is due to lack of infrastructure for the treatment of water and its eventual distribution for the populace. However, limited access to clean and safe water associated with poor water supply, hygiene and sanitation at household level is widening the poverty gap, gender inequalities and the prevalence of water borne diseases (Gender and Water Alliance (GWA), 2006). This has contributed 3.7% of the total global disease burden and 2.2million death each year with women and children in the developing countries being the most affected (World Health Organization (WHO)/United Nations International Children's Emergency Fund (UNICEF), 2008). Although the Millennium

Development goals (MDGs) predicted that "by 2015 the proportion of people without access to safe drinking water and sanitation be very low"² it is anticipated that Africa will only reach the MDGs water target by 2040. 400 million of the people living in Africa will be left without access to safe water with a majority of them being women and children that lives in both rural and urban areas.³ Women are the most vulnerable because in most societies, it is women's responsibility to ensure that there is enough clean and safe water for their households for domestic usage and other purposes.⁴⁻⁷ The World Health Organization (WHO) estimated that more than 20% of the world population (around 1.3billion people) have no safe drinking water and that more 40% of all populations lack adequate sanitation. People in the rural areas in absence of potable water are exposed to the risk of water borne diseases like cholera, typhoid and other environmental implications. There is evidence of widespread contamination of water

resources in many areas of Nigeria. It should however be noted that not all contamination events pose a threat to our health. Anchored on various records of water-related health crises being noted in the Ogbomoso South Local Government (OSLG) Area and Ogbomoso North Local Government (ONLG), this research work focuses on the investigation of the contamination levels of some selected wells in the area and studying their associated health implications on human beings. With the present death of information on such occurrences in the study area, a study of this nature is expected to provide technical explanations on the causes and implications of these incidents of water-borne diseases on human health. The OSLG has a population of 100,815 people and ONLG has the city's largest population with a figure of 235,710 residents. With increase in agricultural activities and domestic chores in the area, there is greater need for the adequate supply of good quality water for the growing population. As the well water is naturally provided to every being, and then the environmental and health implications that were attached to this natural resource cannot be over-emphasized. Therefore, this project is necessary for the assessment and improvement of the quality of water sources in Ogbomoso.

The study areas

Ogbomoso Township is constituted by the North and South local government councils; it is located in the western part of Oyo state of Nigeria. Ogbomoso North Local Government Area came into existence on September 24, 1991, as a result of the splitting of the former Ogbomoso metropolis into two on Tuesday. Ogbomoso North Local Government Area is bounded in the North and the East by Surulere Local Government Area, in the South by Ogbomoso South Local Government Area and in the West by Orire Local Government Area. Ogbomoso North has its headquarters located at Kinnira, Ogbomoso and Ogbomoso North is urban in outlook.⁸ The major occupations of the population are farming, trading, teaching and artisans. The local government is largely populated by the Yoruba but various other tribes are found in their thousands. Most residents of the Ogbomoso metropolis are either Christians or Muslims; a few others freely worship traditional gods. The local government council is constituted by Ten (10) wards and they are: Masifa/Aguodo, Sabo/Taara, Isale-Afon, Okelerin, Osupa, Aaje/Ogunbado, Jagun, Ita-Alasa, Isale-Ora/Saja and Abogunde. Ogbomoso south LGA occupies an area land mass of about 30 square kilometres and is bounded in the north by Ogbomoso North Local Government, in the south by Ogo-Oluwa Local Government, in the east by Surulere Local Government and in the west by Orire Local Government. Ogbomoso South has its headquarters located at Sunsun/Arowomole, Ogbomoso. It's being in the savannah zone makes farming the major occupation of the people of the area. Other occupation they engage in are trading, teaching and artisans. The Ten (10) wards of the local government are: Ibapon, Ijeru I, Ijeru II, Arowomole, Akata, Alapata, Isoko, Ilogbo, Lagbedu/Isapa and Oke-Ola/Farm settlement⁸ (Figure 1).

Water pollution in Ogbomoso North and South Local Government (ONSLG)

Waste accumulating in the study area was found to be produced from various sources. These include:

- i. Domestic waste from households,
- ii. Refuse from commercial offices and business holdings,

- iii. Refuse from the market,
- iv. Animal remains and dung from the abattoir
- v. Trash swept from all kinds of streets including highways arterial and sub arterial roads, e.g. Residue from all types of sanitary facilities in the form of human excreta, toilet papers and the likes.
- vi. Waste from the hospitals,
- vii. Refuse from Community holdings like Schools, Churches, Clubs, mosque etc.
- viii. Dry animal excreta (cows, chickens e t c).

At present, uncontrolled dumping of collected animal excreta in low lying land and canal located in Ogbomoso area is going on. The area is full of dumped solid waste which leads to environmental pollution. The means by which the residents get rid of these wastes is thorough burning and probably if rains fall, sweeps them from location which also leads to the accumulation of the wastes at the drainage system. These could also lead to the run off sweeping away shops and houses and through the blockage of the normal drainage and these could cause a severe loss in lives and properties.⁹

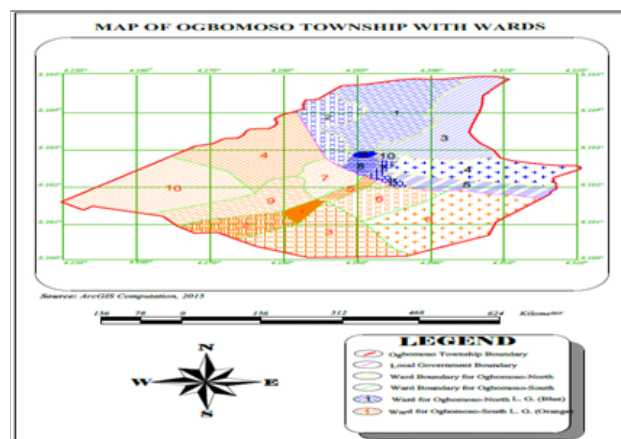


Figure 1 Map of Ogbomoso North and South with constituent wards.

Water Pollutants and their effects on human health

Water pollution has become worldwide concern for the past few decades. It is well known that some heavy metals are harmful and cause tonic effects to human beings. The waste discharged by industries, contain compounds of metals, organic compounds, alkalis, phenols etc, which make water to be polluted. Sewage is the dirty which contains human and animal excretion (urine and faeces). This is produced everyday by human activities like bathing, washing of clothes, kitchen water waste discharge, excreting urine and faeces. Solid waste comprises all the waste arising from human and animal activities. According to World Health Organization (WHO); solid waste is regarded as useless, unwanted or discarded materials arising from domestic, trade, commercial, industrial and agricultural as well as from public services. Some petroleum chemicals can also cause some changes in the behaviour and the physical composition of waste component varies widely with location and season of the year.⁹ The resulting health implications of the existence of these waste pollutants are shown in Tables 1-3.

Table 1 Physical/organoleptic parameters

	Colour	TCU	15	None
Odour	-		Unobjectionable	None
Taste	-		Unobjectionable	None
Temperature	Celsius		Ambient	None
Turbidity	NTU		5	None

Source: (Nigerian standard for drinking water quality, 2007).

Table 2 Inorganic constituents

Parameter	Unit	Max permitted	Health impact
Aluminum (Al)	mg/l	0.2	Potential Neuro-degenerative disorder
Arsenic (As) mg/l	mg/l	0.01	Cancer
Barium	mg/l	0.7	Hypertension
Cadmium (Cd)	mg/l	0.003	Toxic to the kidney
Chloride (Cl)		250	None
Chromium	mg/l	0.05	Cancer
Conductivity	Us/cm	1000	None
Copper	mg/l	1	Gastrointestinal disorder
Cyanide (CN ⁻)	mg/l	0.01	Very toxic to the nervous system
Fluoride	mg/l	1.5	Fluorosis, Skeletal tissue morbidity
Hardness	mg/l	150	None
Iron	mg/l	0.3	None
Lead (Pb)	mg/l	0.01	Cancer, affect mental development
Magnesium	mg/l	0.2	Consumer acceptable
Manganese	mg/l	0.2	Neurological disorder
Mercury (Hg)	mg/l	0.001	Affects the kidney
Nickel (Ni)	mg/l	0.02	Possible carcinogenic
Nitrate	mg/l	50	Cyanosis and asphyxia in infants
Nitrite	mg/l	0.2	Cyanosis and asphyxia in infants
pH	-	6.5-8.5	None
Sodium (Na)	mg/l	200	None
Sulphate	mg/l	100	None
TDS	mg/l	500	None
Zinc (Zn)	mg/l	3	None

Source: (Nigerian standard for drinking water quality, 2007).

Table 3 Microbiological limits

Parameter	Unit	Max permitted Level	Health impact
Total Coliform count	cfu/ml 10	Indication of fecal contamination	Thermo tolerant
Coliform or E.coli	cfu/100ml	0	Urinary tract infections, bacteraemia, meningitis, diarrhea (one of the main causes of morbidity and mortality among children), acute renal failure and haemolyticanaemia
Faecal Contamination	cfu/100ml	0	Indication of recent faecal Streptococcus

Source: (Nigerian standard for drinking water quality, 2007).

Materials and methods

In locating sampling points for the purpose of this project, boreholes, wells and rivers were identified across Ogbomoso, from which water samples were collected. Ogbomoso North and South LGA consists of 10 wards each, five samples were taken from each ward as shown in Figure 1. Thus, a total of 100 water samples were collected. Prior to the collection of water samples from each water source, a thorough familiarization process was embarked on, so as to give advanced knowledge of the location and course of the sample source as well as references to map using Global Positioning Satellite (GPS) for locating coordinates and referencing on map. Figure 2 shows the sample points located on a map of Ogbomoso North and South LGA.

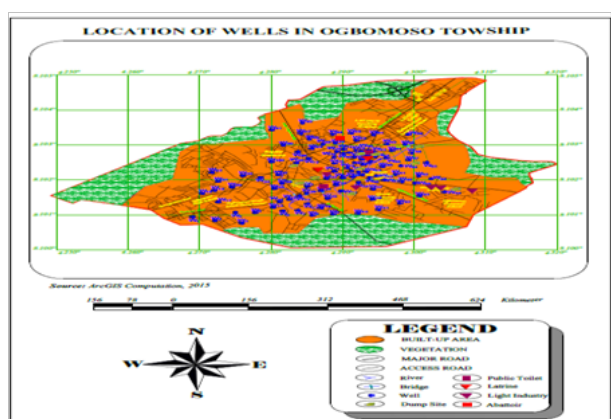


Figure 2 Ogbomoso North and South LGA Map showing location of samples.

Collection of water samples

Samples were taken at several sources within the study area, in order to determine the quality and pollution state of the water source. The samples were collected into acid pre-cleaned high-density 1L polyethylene sampling bottle in order to prevent the risk of contamination and a possibility of influencing laboratory test results. Fifty centilitre (50cl) of water samples was collected from each point using a water sampler. The samples were collected early in the morning to avoid disturbances in the properties like increased temperature as a result of human activities etc. The temperature of the samples was tested immediately using a thermometer. Measurements like salinity, bacteriological properties, and dissolved oxygen could not be determined on site due to unavailability of instrument. Hence, the reason for laboratory tests of each sample. The samples were taken to the water and sanitation laboratory for further analysis.¹⁰⁻¹³

The parameters analysed for

Physical parameters: turbidity, pH value, temperature.

Chemical & Heavy parameters: Sulphate, Phosphate, Calcium hardness, Magnesium hardness, Manganese, Total hardness, Total dissolved solids, Suspended solids, Lead, Mercury, Chromium, Cadmium, Iron, Zinc, Nickel, Copper, Chloride.

Bacteriological parameters: E- Coli, Total coliform.

Results and discussion

The physical, chemical and bacteriological qualities of collected water samples in Ogbomoso North and South local governments areas are presented in Tables 4-6 respectively.

Table 4 Chemical quality of water samples in Ogbomoso North and South Local Government of Oyo State

S/N	Lead mg/l	Manganese mg/l	iron mg/l	Cadmium mg/l	Copper mg/l	Zinc mg/l	Nickel mg/l	Chromium mg/l
1	0.01	3.25	0.01	0.01	0.1	0.09	0.14	0.049
2	0	3.18	0	0.02	0.09	0.05	0.06	0.063
3	0	1.1	0	0.01	0.08	0.06	0.04	0.101
4	0	2.71	0.01	0.02	0.07	0.04	0.03	0.135
5	0.06	4.11	0	0.01	0.07	0.08	0.05	0.152
6	0.04	4.21	0	0.02	0.09	0.15	0.03	0.123
7	0.09	3.05	0	0.04	0.07	0.06	0.02	0.143
8	0	3.2	0	0.04	0.07	0.21	0.12	0.154
9	0.03	3.69	0	0.05	0.06	0.09	0.15	0.167
10	0.02	3.16	0	0.03	0.07	0.05	0.04	0.152
11	0.04	3.9	0	0.01	0.06	0.03	0.04	0.163
12	0.05	2.02	0	0.02	0.06	0.02	0.03	0.143
13	0.08	4.21	0.03	0.03	0	0.12	0.08	0.156
14	0	3.65	0	0.01	0	0.08	0.1	0.167
15	0.03	3.17	0	0.01	0	0.04	0.08	0.168
16	0.05	3.58	0.01	0.05	0	0.13	0.07	0.156

Table Continued

S/N	Lead mg/l	Manganese mg/l	iron mg/l	Cadmium mg/l	Copper mg/l	Zinc mg/l	Nickel mg/l	Chromium mg/l
17	0.07	3.99	0.01	0.04	0	0.17	0.09	0.124
18	0.04	3.62	0	0.01	0	0.2	0.07	0.054
19	0.08	4.13	0	0.01	0	0.21	0.04	0.076
20	0.05	3.06	0	0.02	0	0.05	0.01	0.087
21	0.06	3.42	0	0.03	0	0.07	0.04	0.134
22	0.05	3.78	0	0.04	0	0.09	0.05	0.176
23	0.1	3.57	0	0.03	0	0.14	0.05	0.165
24	0.1	2.78	0	0.04	0	0.18	0.02	0.167
25	0.07	3.9	0.04	0.03	0.01	0.04	0.08	0.178
26	0.05	3.12	0	0.02	0	0.07	0.04	0.189
27	0.04	1.23	0	0.04	0	0.17	0.02	0.145
28	0.09	2.94	0	0	0	0.03	0.01	0.145
29	0.01	2.16	0	0.03	0	0.02	0.02	0.187
30	0.1	2.43	0	0.05	0	0	0.06	0.098
31	0.03	2.95	0	0.06	0	0.23	0.13	0.176
32	0.06	3.85	0	0.05	0	0.06	0.05	0.054
33	0.09	4.46	0	0.03	0	0.06	0.03	0.167
34	0.08	2.8	0	0.06	0	0.04	0.02	0.198
35	0.08	4.31	0	0.02	0	0	0.05	0.076
36	0.05	1.56	0	0.04	0	0.21	0.03	0.187
37	0.07	2.98	0.01	0.05	0	0.12	0.05	0.098
38	0.07	3.61	0	0.06	0	0.05	0.06	0.198
39	0.05	1.86	0	0.02	0.01	0.15	0.08	0.185
40	0.04	2.91	0	0.05	0.07	0	0.06	0.143
41	0.06	3.37	0	0.02	0	0.04	0.02	0.176
42	0.07	4.05	0	0.03	0	0.02	0.14	0.187
43	0.08	1.65	0	0.04	0	0.03	0.17	0.189
44	0.07	2.53	0	0.05	0	0.03	0.12	0.087
45	0.06	2.53	0	0.02	0	0.07	0.15	0.187
46	0.14	1.96	0	0.05	0	0.06	0.03	0.176
47	0.11	2.79	0	0.07	0	0.17	0.06	0.189
48	0.08	2.41	0	0.02	0	0.2	0.03	0.087
49	0.11	2.92	0	0.05	0	0.04	0.05	0.165
50	0.04	2.93	0	0.01	0	0.07	0.17	0.153
51	0.17	2.73	0	0.01	0	0.04	0.08	0.165
52	0.19	2.53	0	0.02	0	0.12	0.08	0.124
53	0.21	1.56	0	0.02	0	0.17	0.09	0.176
54	0.17	1.48	0	0.01	0	0	0.1	0.156
55	0.13	2.91	0	0.03	0	0.24	0.18	0.143
56	0.09	3.01	0	0.02	0	0.08	0.17	0.178
57	0.15	2.34	0	0.05	0.02	0.09	0.05	0.145

Table Continued

S/N	Lead mg/l	Manganese mg/l	iron mg/l	Cadmium mg/l	Copper mg/l	Zinc mg/l	Nickel mg/l	Chromium mg/l
58	0.09	3.27	0	0.04	0	0.18	0.08	0.178
59	0.07	3.23	0	0.03	0	0	0.04	0.125
60	0.06	3.48	0	0.05	0	0.05	0.07	0.178
61	0.11	2.97	0	0.02	0	0.09	0.08	0.167
62	0	3.26	0	0.03	0	0.06	0.09	0.154
63	0.03	3.76	0	0.02	0.01	0.15	0.05	0.178
64	0.13	2.83	0	0.02	0	0.12	0.03	0.154
65	0.08	2.75	0	0.02	0	0.1	0.06	0.167
66	0.02	2.91	0	0.01	0	0.23	0.08	0.168
67	0.01	3.11	0	0.01	0	0	0.16	0.147
68	0.02	2.84	0	0.03	0	0.18	0.09	0.198
69	0.06	2.63	0	0.02	0	0	0.14	0.176
70	0.06	2.92	0	0.02	0	0.21	0.16	0.156
71	0.07	1.92	0	0.01	0	0.12	0.16	0.187
72	0.09	2.44	0	0.03	0	0.13	0.06	0.076
73	0.1	3.21	0	0.02	0	0.09	0.14	0.049
74	0.04	3.41	0	0.02	0	0.03	0.07	0.149
75	0.09	3.03	0	0.04	0	0.02	0.03	0.157
76	0.13	2.63	0	0.03	0.01	0	0.05	0.187
77	0.11	2.64	0	0.05	0	0.3	0.18	0.154
78	0.06	2.91	0	0.01	0	0.16	0.06	0.145
79	0.08	1.98	0	0.02	0	0.28	0.04	0.165
80	0.01	3.16	0.01	0.04	0.02	0.19	0.07	0.135
81	0.17	4.02	0	0.03	0	0.07	0.12	0.168
82	0.07	3.43	0	0.02	0	0.17	0.11	0.178
83	0.06	3.01	0	0.01	0	0.2	0.04	0.186
84	0.05	2.56	0	0.02	0	0	0.02	0.156
85	0.06	2.48	0	0.03	0	0.08	0.09	0.186
86	0.09	2.98	0	0.04	0	0.06	0.04	0.178
87	0.12	3.66	0	0.02	0	0.15	0.17	0.176
88	0.04	3.64	0	0.01	0	0.19	0.09	0.145
89	0.06	2.75	0	0.01	0	0.05	0.11	0.132
90	0.11	2.68	0	0	0	0.09	0.05	0.129
91	0.84	0.57	0.38	0.01	0	0.07	0.14	0.048
92	0.83	0.24	0.38	0	0	0	0.04	0.063
93	0.81	0.7	0.33	0.02	0	0.04	0.05	0.093
94	0.85	2.43	0.32	0	0	0.25	0.15	0.101
95	0.83	0.53	0.33	0	0	0.05	0.05	0.132
96	0.88	0.28	0.35	0	0	0.03	0.06	0.143
97	0.79	0.16	0.31	0	0	0.04	0.06	0.151
98	0.86	0.28	0.3	0	0	0.08	0.05	0.17
99	0.84	0.08	0.28	0	0	0	0.04	0.185
100	0.82	0.59	0.3	0	0	0.24	0.08	0.1998

Table 5 Physio-chemical quality of water samples in Ogbomoso North local government of Oyo State

S/N	Chloride (mg/l)	Calcium (mg/l)	Mg ²⁺ (mg/l)	Total hardness (mg/l)	Sulphate (mg/l)	PO ₄ ²⁻ (mg/l)	Temp. (°C)	pH
1	2.4	12.9	12.5	25.4	370.31	10.36	31.9	5.7
2	4	7.9	7.6	15.5	554.98	10.37	32.1	6.9
3	2.2	4.2	3.9	8.1	604.29	10.37	32	6
4	7	9.5	8.5	18	448.3	10.39	32.3	6.8
5	10.8	9.7	7.8	17.5	439.34	10.36	32	6.6
6	3.1	11.5	10.1	21.6	549.6	10.36	32.1	6.6
7	10.8	4.2	3.3	7.2	537.05	10.48	31.8	7.2
8	8.2	11.3	5.9	17.2	537.06	10.36	32	6.7
9	3	8.7	7.6	16.3	103.15	10.33	32	6.6
10	7.3	10	8.4	18.4	156.94	10.37	32.5	6.6
11	10.4	14.7	11.3	26	129.15	10.48	32.8	6.3
12	3.4	10.3	8.8	19.1	151.56	10.38	32	6.6
13	9.2	7.3	5.3	12.6	268.11	10.37	32.2	6.7
14	9.5	7	4.9	11.9	275.28	10.38	32.2	5.5
15	7.7	14.2	11.6	25.8	351.48	10.39	32.9	6.4
16	5.6	7.1	5.6	12.7	143.49	10.36	32.8	6.6
17	6.2	11.9	11.1	23	496.71	10.33	32.6	6.6
18	6.2	4.8	4.09	8.89	168.6	10.46	32.3	6.6
19	10.9	11.4	9.81	21.21	308.45	10.36	33	7.3
20	11.9	10.4	8.3	18.7	306.66	10.33	33	7.3
21	9.7	7.7	6.2	13.9	234.94	10.36	32.7	6.4
22	9.9	6.2	4.5	10.7	238.52	10.48	32	6.8
23	9.4	10	9.3	19.3	165.01	10.35	32.6	6.9
24	11.8	6.9	6	12.9	300.38	10.5	32	6.9
25	11.9	6.6	6.09	12.69	271.69	10.51	32.6	7.1
26	5.3	3.3	3.01	6.31	198.18	10.38	32.1	6.6
27	6.4	2.8	2.4	5.2	278.86	10.43	32.5	6.5
28	6.1	3.5	2.6	6.1	258.25	10.52	32.7	6.6
29	4.2	3.1	2.8	5.9	470.71	10.51	32.5	7
30	8.3	5.5	4.9	10.4	469.82	10.39	32	6.4
31	12	5.2	4.8	10	166.8	10.39	32.4	6.5
32	13.2	5.7	5.2	10.9	253.76	10.37	32	6.4
33	9.2	7.2	6.8	14	263.62	10.48	32.2	6.1
34	8.9	10.7	10.3	21	253.76	10.5	32.1	6.6
35	9.5	4.8	4.5	9.3	284.24	10.51	32	6.7
36	8.9	3	2.8	5.8	271.69	10.52	32.3	6.4
37	8	3.3	3.1	6.4	142.6	10.51	32.4	6.5
38	7.2	5.6	5.2	10.8	447.41	10.31	32	5.9
39	7.7	7.9	7.3	15.2	302.17	10.512	32.2	5.9

Table Continued

S/N	Chloride (mg/l)	Calcium (mg/l)	Mg ²⁺ (mg/l)	Total hardness (mg/l)	Sulphate (mg/l)	PO ₄ ²⁻ (mg/l)	Temp. (°C)	pH
41	6	11.5	11	22.5	469.82	10.5	32.1	6.3
42	8.9	3	2.8	5.8	199.97	10.32	32.6	7
43	8.9	4.1	3.9	8	301.28	10.33	32.7	5.9
44	5.7	8.2	5.1	13.3	300.38	10.32	32.8	6.5
45	10.3	8.3	8.2	16.5	292.31	10.51	33	5.5
46	9.1	9.9	9.2	19.1	273.49	10.32	32.1	6.9
47	8	6.3	6.1	12.4	299.48	10.33	32	7
48	7	8.3	7.9	16.2	614.15	10.36	32.3	6.9
49	8.2	6.1	5.8	11.9	606.08	10.32	32.7	5.4
50	11.1	6.1	6	12.1	434.85	10.35	32.6	7.1
51	7.4	5.5	5.2	10.7	586.36	10.36	32.2	6.7
52	8.9	2.8	2.7	5.5	312.93	10.35	32	6.1
53	9.5	2.3	2.2	4.5	411.55	10.33	32.8	6.3
54	9.9	4.8	4.3	9.1	559.47	10.32	32.6	5.6
55	12.7	4.4	4.3	8.7	551.4	10.33	32	6.1
56	12.9	6.2	6	12.2	479.68	10.35	32.4	7.4
57	12.1	7.2	7	14.2	380.17	10.34	32.3	5.3
58	11.7	5.1	4.9	10	483.26	10.34	32	5.5
59	10.3	4.7	4.5	9.2	380.17	10.34	32.2	5.7
60	11.3	8	4.4	12.4	497.61	10.34	32.2	6
61	5.8	8.4	8	16.4	406.17	10.33	32	5.3
62	9.6	7.4	7.1	14.5	463.54	10.32	32	5.9
63	7.3	8	7.7	15.7	461.75	10.33	33	5.3
64	6.8	8.2	8	16.2	470.71	10.35	32.1	6.7
65	5.7	3.7	3.4	7.1	316.52	10.34	33	6.6
66	10.1	5.8	5.6	11.4	327.28	10.35	32.8	6.2
67	9	4.6	4.5	9.1	371.2	10.34	33	6.3
68	12.1	6.5	5.9	12.4	370.31	10.34	32.8	6
69	11.1	5.5	5.4	10.9	425.89	10.37	38	6.9
70	10.7	6.5	6.2	12.7	362.24	10.57	32.8	7.1
71	8.9	7.7	7.6	15.3	454.58	10.35	33	6.2
72	6	6.2	5.9	12.1	465.33	10.33	32.8	5.9
73	8.9	5.8	5.5	11.3	434.85	10.34	33.2	5.6
74	7.6	8.1	7.9	16	424.1	10.35	33	6.1
75	6.6	6.1	5.8	11.9	559.47	10.33	33	5.7
76	6.5	7.1	6.9	14	360.45	10.33	32.8	5.6
77	7.3	6.1	5.9	12	351.48	10.36	32.4	6.3
78	6.7	6.9	6.5	13.4	481.47	10.34	32.5	5.8
79	8.6	5.6	5.4	11	397.2	10.34	32.8	6.3
80	10.1	8.3	8	16.3	369.41	10.34	33	5.9
81	7.4	7.3	7.1	14.4	554.09	10.33	32.9	5.7
82	5.8	5.7	5.5	11.2	532.57	10.39	32.8	7

Table Continued

S/N	Chloride (mg/l)	Calcium (mg/l)	Mg ²⁺ (mg/l)	Total hardness (mg/l)	Sulphate (mg/l)	PO ₄ ²⁺ (mg/l)	Temp. (°C)	pH
83	9.4	6.3	6	12.3	551.4	10.4	33.8	6.4
84	8.4	6.8	6.6	13.4	541.54	10.36	33.1	6.7
85	6.3	7.1	6.9	14	517.33	10.36	33	6.7
86	5.2	6.1	5.8	11.9	539.74	10.35	32.6	6.2
87	7.7	7.7	7.4	15.1	405.27	10.33	32.6	6.6
88	6.6	8.6	8.3	16.9	554.98	10.39	32.9	6
89	9.3	5.6	5.3	10.9	370.31	10.38	33.1	5.4
90	5.5	7	6.7	13.7	411.55	10.35	32.5	5.8
91	2.3	3.8	27.1	30.9	518.23	10.37	24.5	7
92	4.4	4.3	13.1	17.4	698.42	10.38	25	6.6
93	5.7	4	5.3	9.3	860.69	10.45	25	6.7
94	4.9	2	9	11	751.31	10.47	25.5	6.8
95	4.9	2	9.8	11.8	827.52	10.34	26	7
96	5.9	2	9.4	11.4	751.32	10.48	24.5	6.8
97	8.2	3	20.1	23.1	598.02	10.33	24	7.2
98	7.8	3.3	24.2	27.5	688.56	10.48	24	7
99	5.6	3.8	29.9	33.7	676.01	10.32	24.5	7
100	7.2	4	11.5	15.5	819.45	10.34	24	6.6

Table 6 Physical and bacteriological quality of water samples in Ogbomoso North and South local government

S/N	Suspended solids mg/L	Dissolved solids mg/L	Total solids mg/L	E-coli mg/L	T-coli mg/L	Turbidity mg/L
1	70	30	100	48	20	0
2	30	20	50	48	48	0
3	62	40	102	44	44	0
4	10	60	70	46	32	0
5	17	20	37	36	40	0
6	30	50	80	40	32	0
7	40	80	120	24	40	0
8	19	30	49	32	40	1
9	30	40	70	54	20	0
10	20	50	70	60	52	0
11	30	30	60	20	32	0
12	73	80	153	36	40	0
13	70	60	130	36	36	0
14	20	100	120	16	40	0
15	110	90	200	48	41	0
16	60	80	140	36	30	0
17	20	30	50	40	42	0
18	130	60	190	28	32	0
19	40	60	100	42	30	0
20	20	30	50	44	38	0
21	120	60	180	32	26	0

Table Continued

S/N	Suspended solids mg/L	Dissolved solids mg/L	Total solids mg/L	E-coli mg/L	T-coli mg/L	Turbidity mg/L
22	120	30	150	32	32	0
23	20	30	50	42	40	0
24	110	40	150	34	44	0
25	33	10	43	50	32	0
26	40	30	70	46	28	0
27	20	40	60	40	24	0
28	22	20	42	48	30	0
29	60	60	120	36	32	0
30	70	10	80	28	36	0
31	17	46	63	36	38	0
32	81	40	121	42	40	0
33	82	63	145	32	56	0
34	40	100	140	42	42	0
35	42	30	72	50	22	0
36	48	120	168	62	46	0
37	59	120	179	42	44	0
38	46	55	101	40	28	0
39	116	50	166	38	42	0
40	75	49	124	34	48	0
41	45	65	110	34	52	0
42	60	88	148	46	48	0
43	54	80	134	40	32	0
44	43	73	116	26	38	0
45	66	100	166	40	38	0
46	76	90	166	44	32	0
47	32	58	90	42	43	0
48	26	60	86	36	48	0
49	32	56	88	36	40	0
50	40	60	100	42	38	0
51	65	44	109	40	56	0
52	60	60	120	40	44	0
53	58	43	101	32	40	0
54	60	56	116	52	44	0
55	62	34	96	44	36	0
56	58	40	98	32	40	0
57	60	60	120	32	28	0
58	65	78	143	32	44	0
59	72	84	156	24	28	0
60	68	32	100	52	68	0
61	68	54	122	38	43	0
62	56	66	122	44	32	0
63	50	78	128	50	42	0
64	70	36	106	48	36	0

Table Continued

S/N	Suspended solids mg/L	Dissolved solids mg/L	Total solids mg/L	E-coli mg/L	T-coli mg/L	Turbidity mg/L
65	76	98	174	68	60	0
66	55	90	145	44	44	0
67	65	54	119	34	24	0
68	60	52	112	44	36	0
69	43	60	103	36	46	0
70	25	64	89	40	32	0
71	44	28	72	42	60	0
72	65	26	91	56	32	0
73	66	42	108	46	20	0
74	45	46	91	20	48	0
75	60	86	146	44	46	0
76	44	65	109	48	44	0
77	70	28 98	32 24	0		0
78	26	50	76	40	52	0
79	63	98	161	40	32	0
80	66	68	134	44	40	0
81	20	80 100	40 36		0	0
82	28	70	98	36	42	2
83	21	70	91	46	44	1
84	46	45	91	42	48	0
85	30	70	100	44	44	0
86	45	70	115	38	46	0
87	80	65	145	20	36	0
88	80	50	130	64	40	0
89	60	65	125	48	24	0
90	48	55	103	32	28	1
91	80	60	140	36	30	0
92	15	60	75	23	27	0
93	70	70	140	31	28	0
94	55	85	140	45	35	0
95	60	50	110	20	19	0
96	100	35	135	26	30	0
97	60	65	125	19	13	0
98	85	15	100	28	30	0
99	80	35	115	14	12	0
100	20	30	50	16	18	0

Discussion

pH

The pH value of tested water samples ranged from 5.3 to 7.40. Results of tests on Samples 57, 61 and 63 taken from Akata (Abidogun 3 house), Ibadan (Ola-Oluwa Communications) and Ijeru (Bathel Baptist Church) respectively showed the least pH value of 5.3 indicating its acidity. pH values of samples 1,3,11,14,15,21,30,32,33,36,38,39,41,43,45,49,54,57,58,59,60,61,62,63,66,67,68,71,72,73,

74,75,76,77,78,79,80,81,83,86,88,89 and 90 fall below the NIS and WHO standards of range 6.5-8.5. These water samples are likely to have metallic or sour taste, resulting from the leaching of metals from the surroundings to the water source.

Lead (Pb)

The Lead value ranged from 0.0mg/l to 0.88mg/l. Samples 2, 3, 4, 8, 14 and 62 shows the lowest value (0mg/l) while sample 96 shows the highest value (0.88mg/l). All samples exceed the limit of N.I.S

and below W.H.O standard of 0.01mg/l and 1.05mg/l respectively. Table 4 shows the concentration of lead in the water samples. Higher lead concentration in sample is as a result of presence of batteries, burnt tires. Research shows that people who drink water containing Lead in excess of the action level may experience delay in physical and mental development with short term exposure while in adult may cause blood pressure and adult who drink over many years could cause kidney problem.

Chromium

The Chromium value ranged from 0.048mg/l to 0.199mg/l. Sample 91 shows the lowest value (0.048mg/l) while sample 100 shows the highest value (0.199mg/l). Samples 1, 2, 3 are within the range of WHO of 0.05mg/l while all samples are over NIS standard 0.1mg/l. Table 4 shows the concentration of Chromium in the water samples. Higher Chromium concentration in sample was a result of presence of batteries and industrial waste. Research shows that people who drink water containing Chromium in excess of the action level may with experience lung, respiratory tract cancer and kidney diseases short term exposure and with long term exposure causes diarrhea.

Zinc (Zn)

The Zinc value ranged from 0.00mg/l to 0.3mg/l. Samples 30, 35, 40, 54, 59, 67, 76, 84, 92 and 100 shows the lowest value (0.00mg/l) while sample 79 shows the highest value (0.3mg/l). All samples are within the range of NIS and WHO standard of ≤ 5 mg/l. Table 4 shows the concentration of Zinc in the water samples. Higher Zinc concentration in samples is as a result of presence of batteries and vehicles emission within the area. Research shows that people who drink water containing Zinc in excess of the action level may with short term exposure experience fever and intestinal disturbance.

Manganese (Mn)

The Manganese value ranged from 0.08mg/l to 4.46mg/l. Sample 99 shows the lowest value (0.08mg/l) while sample 33 shows the highest value (4.46mg/l). Samples 7 and 9 are within the range of NIS and WHO standard of 0.2mg/l and 0.2mg/l respectively. Table 4 shows the concentration of Manganese in the water samples. Higher Manganese concentration in sample is as a result of industrial waste and vehicle emission as they are the major source of Manganese within the area. Research shows that people who drink water containing Manganese in excess of the action level may cause damage of central nervous system, weakness and fatigue.

Nickel (Ni)

The Nickel value ranged from 0.01mg/l to 0.18mg/l. Samples 20 and 28 shows the lowest value (0.01mg/l) while samples 55 and 77 shows the highest value (0.18mg/l). All samples contain Nickel concentration above the range of NIS and WHO standard of 0.02mg/l except samples 7, 20, 24, 28, 29, 34, 41 and 84. Table 4 shows the concentration of nickel in the water samples. Higher Nickel concentration in sample is as a result of vehicle emission contamination as they are the major source of Nickel within the area. Research shows that people who drink water containing Nickel in excess of the action level may experience lung cancer.

Cadmium (Cd)

The Cadmium value ranged from 0.00mg/l to 0.07mg/l. Samples 28, 90, 92, 94 to 100 shows the lowest value (0.00mg/l) while sample 47 shows the highest value (0.07mg/l). Most samples are within

the range of NIS and WHO standard of 0.03mg/l and 0.05mg/l respectively, only samples 31, 34, 38 and 47 exceed the regulatory limits. Table 4 shows the concentration of Cadmium in the water samples. Higher Cadmium concentration in sample is as a result of presence of electroplating, batteries as they are the major source of Cadmium within the area. Research shows that people who drink water containing Cadmium in excess of the action level may experience fatigue, headache and vomiting.

Iron (Fe)

The Iron concentration value ranged from 0.0 to 0.38. Samples 2, 3, 5, 12, 14, 15, 18-24, 26-36, 38-79 and 81-90 shows the lowest value (0.0) while samples 91 and 92 shows the highest value (0.38). All samples are within the range WHO standard and NIS standard of 0.3mg/l and 1mg/l respectively. Table 4 shows the concentration of Iron in the water samples. Higher Iron concentration in sample is as a result of vehicle emission and industrial waste as they are the major source of Iron within the area. Research shows that people who drink water containing Iron in excess of the action level may experience nausea, abdominal pain and gastrointestinal bleeds.

Copper (Cu)

The Copper value ranged from 0.0mg/l to 0.1mg/l. Samples 13-24, 26-38, 41-56, 58-62, 64-75, 77-79 and 81-100 shows the lowest value (0.0mg/l) while sample 3 shows the highest value of copper present. All samples are within the range of NIS and WHO standard of 1mg/l and 1.5mg/l respectively. Table 4 shows the concentration of Copper in the water samples.

Temperature

The temperature value ranged from 24°C to 38°C. Samples 97, 98 and 100 shows the lowest value (24°C) while sample 71 shows the highest value (38°C). All samples are within the range of NIS and WHO standard of 39.7°C. Table 5 shows the concentration of temperature in the water samples.

Chloride (Cl-)

The Chloride value ranged from 2.2mg/l to 13.2mg/l. Sample 3 shows the lowest value (2.2mg/l) while sample 32 shows the highest value (13.2mg/l). All samples are within the range of NIS and WHO standard of 100mg/l and 600mg/l respectively. Table 5 shows the concentration of Chloride in the water samples.

Phosphate (Po4-)

The Phosphate value ranged from 10.32mg/l to 10.57mg/l, sample 99 shows the lowest value (10.32) while sample 70 shows the highest value (10.57). All samples are well over the range of NIS and WHO standard both of 5mg/l. Table 5 shows the concentration of phosphate in the water samples. Higher Phosphate concentration in sample is as a result of septic waste, fertilizer run-off and improper treatment of waste water contamination as they are the major source of Copper within the area. Research shows that people who drink water containing Phosphate in excess of the action level may experience liver or kidney damage.

Sulphate (So42-)

The Sulphate value ranged from 103.15mg/l to 860.67mg/l. Sample 9 shows the lowest value (103.15mg/l) while sample 93 show the highest value (860.67mg/l). Only samples 9, 10, 11, 12, 16, 18, 21, 22, 26, 31, 37 and 42 are within the range of NIS and WHO standard of

250mg/l. Table 5 shows the concentration of Sulphate in the water sample. Higher Sulphate concentration in sample is as a result of movement of water through soil and formation that contain Sulphate minerals. Research shows that people who drink water containing Sulphate in excess of the action level may experience diarrhea and dehydration.

Calcium hardness

The Calcium hardness value ranged from 2.00mg/l to 14.70mg/l. Samples 96, 97 and 98 shows the lowest value (2.00mg/l) while sample 13 shows the highest value (14.7mg/l). All samples are within the range of NIS and WHO standard of 30mg/l. Table 5 shows the concentration of Calcium hardness in the water samples.

Magnesium hardness

The Magnesium hardness value ranged from 2.2mg/l to 29.9mg/l. Sample 53 shows the lowest (2.2mg/l) while Sample 99 shows the highest value (29.9mg/l). Some samples are within the range of NIS and WHO standard, both of 30mg/l. Table 5 shows the concentration of Magnesium hardness in the water samples compared with the NIS and WHO standard. Higher Magnesium concentration in sample is as a result of dissolved Magnesium and Calcium ions when getting contact with limestone and other rocks that contain Calcium compound. Research shows that hard water was not that harmful to health but can pose serious problems in industrial setting.

Total Hardness

The total hardness value ranged from 4.5mg/l to 33.7mg/l. Sample 53 shows the lowest value (4.5mg/l) while sample 99 shows the highest value (33.7mg/l). All samples are within the range of NIS and WHO standard of ≤ 10 mg/l and ≤ 50 mg/l respectively. Table 5 shows the concentration of total hardness in the water samples. High hardness concentration in sample is as a result of dissolved Magnesium and Calcium ions when getting contact with limestone and other rocks that contain calcium compound. Research shows that hard water was not that harmful to health but can pose serious problems in industrial settings.

Suspended solids

The suspended solid value ranged from 10mg/l to 130mg/l. Sample 7 shows the lowest value (10mg/l) while sample 18 shows the highest value (130). All samples are within the range of NIS and WHO standard of ≤ 100 mg/l and ≤ 150 mg/l respectively. Table 6 shows the concentration of suspended solid in the water samples. Research shows that people who drink water containing suspended solid in excess of the action level may suffer from heart and kidney diseases.

Dissolved solids

The dissolved solids concentration value ranged from 10mg/l to 120mg/l. Sample 25 shows the lowest value (10mg/l) while sample 30 shows the highest value (120mg/l). All samples are within the range of NIS and WHO standard of ≤ 150 mg/l and ≤ 500 mg/l respectively. Table 6 shows the concentration of dissolved solids in the water samples. Research shows that people who drink water containing dissolved solid in excess of the action level may affect person who are suffering from heart and kidney diseases.

Total solids

The Total Solid value ranged from 37mg/l to 200mg/l. Sample 5

shows the lowest value (37mg/l) while sample 15 shows the highest value (200mg/l). All samples are within the range of WHO standard of ≤ 500 mg/l while only samples 12, 15, 18, 21, 36, 37, 39, 45, 46, 59, 65 and 79 exceeds NIS standard of ≤ 150 mg/l. Table 6 shows the concentration of Total Solid in the water samples compared with NIS and WHO standard. Research shows that people who drink water containing total solid in excess of the action level may affect person who are suffering from heart and kidney diseases.

E-coli

E-coli ranged from 14mg/l to 68mg/l. Sample 99 shows the lowest concentration (14mg/l) and sample 65 shows the highest concentration (68mg/l). NIS and WHO does not allow any number of E- Coli as they play major role in the contribution in spreading of so many diseases. All samples failed to conform to standard. High values of *E-coli* can be attributed to improper sewage disposal measures. Table 6 shows the concentration of E-coli. Research shows that people who drink water containing *E-coli* in excess of the action level may die.

T-Coliform

T-coli ranged from 12mg/l to 68mg/l. Sample 99 shows the lowest concentration (12mg/l) and sample 60 shows the highest concentration (68mg/l). NIS and WHO does not allow any number of T-coliform as they play major roles in the contribution in spreading of so many diseases. All samples failed to conform to standard. High values of T-coliform can be attributed to improper sewage disposal measures. Table 6 shows the concentration of T-coliform compared with NIS and WHO standard. Research shows that people who drink water containing single T-coli in excess of the action level may result to death especially for children.

Conclusion and recommendations

Conclusion

Concentration of various constituents of potable water exceeding the regulatory limits set by standard organizations; affect the use of water in some areas. This research work was channelled in this light and the following conclusions were drawn in the process: The quality of water consumed by residents of the study area has significant health implications which have been discussed comprehensively in this research work. The project serves as an insight to this informative assignment that involves water sample collection in the area, laboratory tests and analyses of these results. The quality of water is a measure of its physical, chemical and bacteriological characteristics. This project justifies the above assertion by analysing the water parameters with respect to their physical, chemical and bacteriological properties. For many aquifers within the study area, the water available for consumption satisfies the safe potable water criteria, except few exemptions identified during the course of study. Properties of tested water samples like Manganese, Nickel, Chromium, Phosphate, Sulphate, T-Coliform and E- Coliform were found to be in excess as shown in Figure 3. T-Coliform, E-Coliform concentration in the tested water samples across Ogbomoso North and South LGA were observed to be in excess. This high Total Coliform counts and *E-Coli* in water samples can be attributed to presence of septic tanks, latrines, dumpsites and indiscriminate disposal of sewages which are responsible for incidence of water borne diseases in the area (Figure 3).

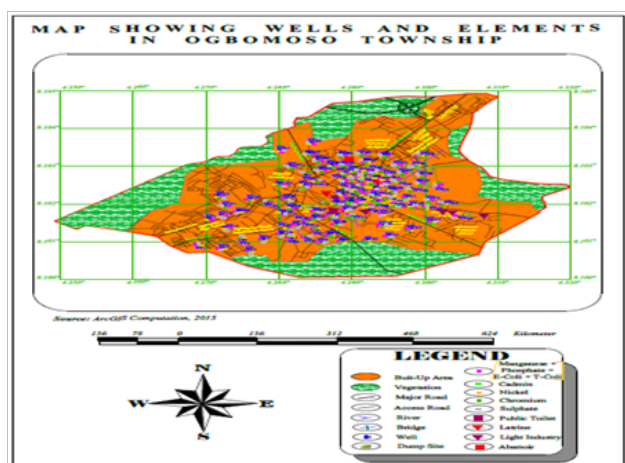


Figure 3 Water quality map for Ogbomoso North and South Local Government Area.

Recommendations

The following recommendations were made with respect to the results of analysis made on water samples in the study area:

Land use control, community mobilization, sensitization, public enlightenment, adequate collection and disposal of solid waste and prevention of grey water from bathrooms and kitchen discharge through adequate provision of drainage facilities are necessary measures to adopt towards maintaining quality potable water. Provision of well-constructed comfort stations in the area especially Agbowo and Ilogbo wards in Ogbomoso North and South LGA respectively is an urgent control measure needed. The nearness of wells to the dumpsites increases their state of pollution due to leachates migration. It is recommended that wells be dug with considerable distance from contamination sources. These wells should be properly lined and covered. It is recommended that the Nigeria Industrial Standard (NIS) saddled with the responsibility of ensuring a sustainable and healthy environment. They should develop effective measures to protect the water sources from pollution by residents, motorists and industries within the area. Government and residents of Ogbomoso South LGA especially Osupa, should work together towards making good quality water available by creating boreholes and pumps, as there are very few existing ones. Bacteriological quality of the samples in both areas is poor and unsuitable for human consumption without treatment. The bacteriological quality of the samples should be monitored by

conducting a periodic on-site inspection by assessing how vulnerable the source of water is, to nearby sources of faecal contamination, testing its source-water quality periodically and disinfect water to eliminate any form of pathogens present in water.

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None.

Conflict of interest

The author declares no conflict of interest.

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