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Assessment of Geochemistry of Surface and Groundwater Sources During the Dry Season in Uhonmora-Ora Owan-West Local Government Area, Edo State, Nigeria

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Abstract

The presence of heavy metals and biological characteristics in surface and groundwater sources in Uhonmora-Ora during the dry season was undertaken. Physicochemical parameters examined include pH, turbidity, dissolved oxygen, total dissolved solids, total suspended solids, and electrical conductivity. The concentrations of heavy metals such as Iron, Cadmium, Calcium, Copper, Magnesium, Lead, and Zinc were examined. The bacteriological parameters were counts for pneumonia, coli, typhi, and aerogenes. The study's objective was to assess the physicochemical and biological characteristics of groundwater quality during the dry season in conformity with WHO and NSDWQ standards. Data were obtained from primary and secondary sources. Data from sixty surface and groundwater samples from streams/rivers and hand-dug wells across the eight quarters were analysed. Results showed that a combination of very high and positive correlations exists between and among the tested parameters. However, variations exist within and among the mean concentration of NTU, DO, TSS, TDS, Fe, Cd, Cu, Ca, Ma, Pb, Zn, K, E, S, and Ea parameters in surface and groundwater sources. The study also revealed that the rate of shared contaminants of surface and groundwater sources was higher during the dry season than in the wet season. The study recommends that at regular intervals, samples from these water sources should be assessed and the outcome made available to researchers for cross-examination and remediation to improve human health.

Keywords: Geochemistry, Heavy Metals, Surface and Groundwater Sources, Dry-Season.

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Introduction

Water is a universal solvent, that dissolves many substances, and its solubility increases with increasing temperature. Water is a remarkable catalyst as many reactions may be slow or inhabited by lack of water (Chapman, 1996). Water is a clear thin liquid that has no colour or taste when it is pure. Water is formed into the cloud after the hydrological processes, water falls from the cloud and gets to the earth's surface in diverse forms of precipitation (Strahler and Strahler, 2006). These forms of precipitation flow into water bodies and percolate into the soil which is termed as surface and groundwater sources. Water is essential and gives life to man and other living organisms but when the water is not well managed and treated, it leads to loss of life. During these processes and other attributes such as states, movements, land use, and seasonality, the quality of water is lower and there is a need to ascertain its suitability for human consumption (Akoteyon and Soladoye, 2011; Soladoye and Agbebaku, 2015; WHSWQ, 2021). Surveys have shown that the quality of water sources varies from one geographical location to another, depending on the land use function influenced by humans and the geology of the underlying bedrock influenced by recharge and discharge by natural processes (Ayeni, Balogun and Soneye, 2011; Agbebaku, Okhae, Abu, Ari, Ojo & Saiki, 2023). The rate of groundwater loss is higher in the dry season than in the wet season. The advancement of the dry season and drought conditions or a combination compels surface water to shrink, skew and dry up far below the water table. During these processes and seasons, water concentration is confined into the confined aquifer zone where there is higher infiltration than leaching (Wright and Boorse, 2011; Soladoye and Agbebaku, 2015; Agbebaku, Raleigh and Afolayan, 2022). The first heavy rainfall after a spelt dry season flushed high concentrations of gasoline, lead, and rubber residues from the surface to groundwater sources thereby enhancing its quality (Soladoye and Agbebaku, 2015; Agbebaku et al 2023). Since the inception of the Uhonmora-Ora, the community has been relying on the combination of water sourced from streams, rivers, hand-dug wells, and rainwater supplies for their sustainability. This is because the community is unable to connect to the central water supply system from the Edo State Water Board (ESWB). Subsequently, the collapse of the central pipe-borne water supply in the Afuze community close to Uhonmora-Ora over 35 years ago led to the discovery of the artesian aquifer and bole-hole establishments in Sabongida-Ora, a neighbouring community. On the use of surface water sources for drinking and cooking purposes, the indigenous people of Uhonmora-Ora believe that flowing or freshwater sources can never be contaminated but get purified naturally in the course of movement. According to Ohimai (2023), about 85% of the groundwater sources from hand-dugs wells are open and exposed to dust and gasoline particles throughout the season. There are counting records of where domestic animals, defecate and urinate in these facilities and their feces leached into groundwater sources. Despite these challenges, the people of Uhonmora-Ora, believe that flowing water can never be contaminated but get purified naturally in the course of movement (Atafo, 2023; Ohimai, 2023).

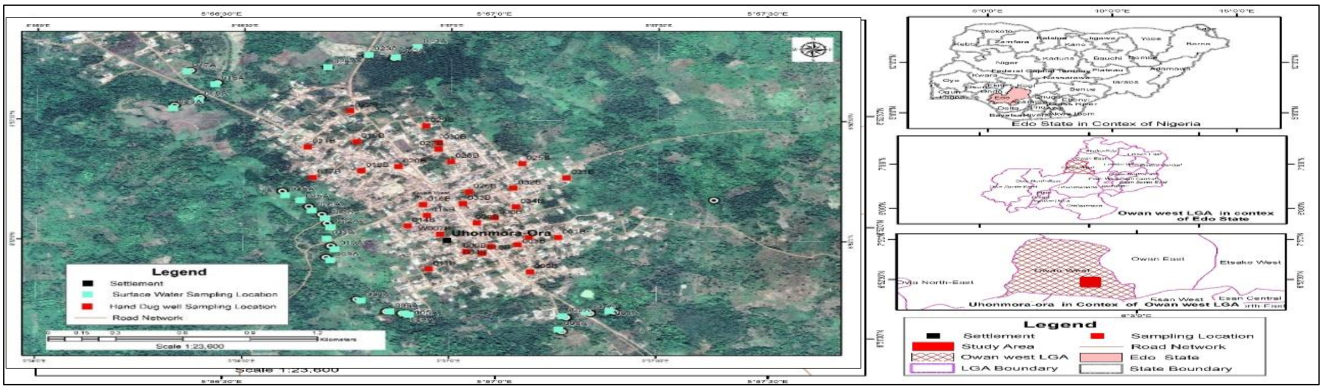
Also, worrisome in the community is the proximity of sucker ways dug close to hand-dug wells on account of the clustered houses and poor physical planning and space management in the community. In addition, the increasing use of chemicals and pesticides for farming purposes has been on the increase. Thus, on an annual basis during the peak of the dry season, the indigenes still engaged in the rudimentary practice of annual pollution of surface water sources with chemical substances such as Gammalin 20 and D.D fox, to kill and harvest fish for human consumption (Ohimai, 2023; Atafo, 2023). Given these ill practices, the constituent effect on human health is the prevalence of cases of fever, typhoid, malaria and cholera in the community. The concern about these ill practices and threats of diseases has been on the increase in the past ten decades. The cost implication of treatment for these ailments despite their low-income status and the gradual collapse of their traditional values of self-medication are added factors to the need for quality water sources in the community (Ohimai, 2023; Atafo, 2023; Majebi and Agbebaku, 2023). Many studies on water quality have been carried out in most rural communities in Edo State, but none of these studies have been done in Uhonmora-Ora despite these challenges. Subsequently, the seasonal pollution of shared contaminants, movement of sediments, coloration, taste and human attitudes towards water management compelled the researcher to examine the safety of the supply of these sources of water to human health during the dry season and thus, the research gap. In other to achieve this aim, the objective of the study is to assess the physicochemical and biological characteristics of surface and groundwater sources during the dry season in Uhonmora-Ora.

Materials and Methods

Uhonmora–Ora is one of the six Ora communities in Owan West Local Government Area, Edo State, Nigeria. The Community is located between Latitude 6^0 10ʾN and 6^0 45ʾN and Longitude 6^0 10ʾE and 6^0 40ʾE. The community is bounded to the North by Sabongida-Ora, North-East by Eme-Ora and South by Ozalla communities of the Ora clan that constitute parts of the Owan-West Local Government Area. Uhonmora-Ora comprises eight quarters which include; Oduosi, Ukpafoga, Ukhuedeodu, Ukpafisi, Ukpokhunmu, Ukpafekhai, Ukpafortisi and Ukhuoro. The community is characterized by a relatively flat and simple undulating topography of about

78.64 meters above sea level and records its highest temperature (36.1^{0}C) in February and March and the lowest temperature (19.4^{0}C) in April and May. The community experiences heavy rainfall between March and November every year. The community's annual rainfall is between 2000mm and 3000mm. The area is well-drained by three major Rivers which are perennial and several streams of water sources which are seasonal. The perennial rivers are River Owan, River Oruen and Obvioti River. These significant rivers meandered and cut across eight-quarters of the community. The community is underlain by sedimentary rocks and brownish earth which supports the production of food and cash crops such as plantain, garri, palm oil and cocoa products in the State and Nigeria as a whole (Ohimai, 2023; Atafo, 2023). The community has a population of 785,676 in 2016 (NPC, 2016).

Both primary and secondary data collection were implored to facilitate the research. The primary source comprised mainly of field observations, sample collection and mapping of the



study area. The secondary data explored were sourced from documentary materials and established sources. Since the research was purely experimental, data from primary sources were mainly relied on for the study. A total of 60 water collection points for the dry season (March 2023). That is, SUA001 – SUA025 for surface water sources (rivers/streams), and GWB001 – GWB035 for groundwater sources (hand-dug-wells) in the study area. Mapping of the study area was generated using geo-informatic tools such as Global Positioning System (GPS) and Geographical Information System (GIS) techniques. The global positioning system (GPS) Garmin Channel 78. SC model was used to determine the coordinates (x, y). The derived maps with insets of Edo State, Owan West Local Government Area and Uhonmora-Ora community as presented in Figures 1 to 3. Figure 1, shows the sampling points of 25 surfaces and 35 groundwater sources, Figure 2, shows the Ph of water from Uhonmora – Ora, and Figure 3, shows the three major rivers in Uhonmora – Ora used for the study. These maps were generated from the Departments of Geography and Planning, Lagos State University, Ojo and Kogi State University, and Anyigba respectively.

Figure 1: Sampling Location Imagery of the Rivers in Uhonmora - Ora.

Source: GIS and Cartography Unit, Kogi State University, Anyigba (2023).

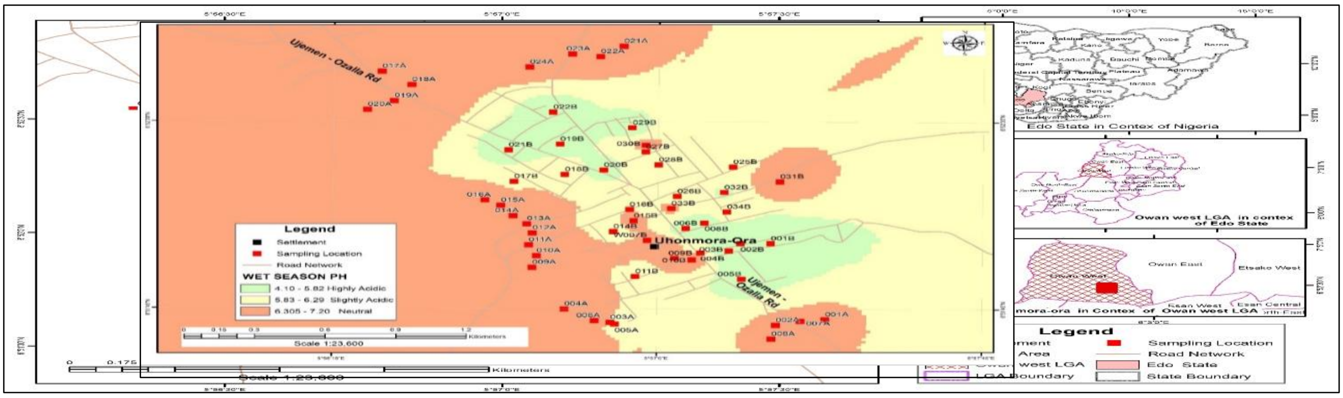


Figure 2: Plot of pH of Water Readings along with Sample Numbers from Uhonmora - Ora.
Source: GIS and Cartography Unit, LASU (2023)

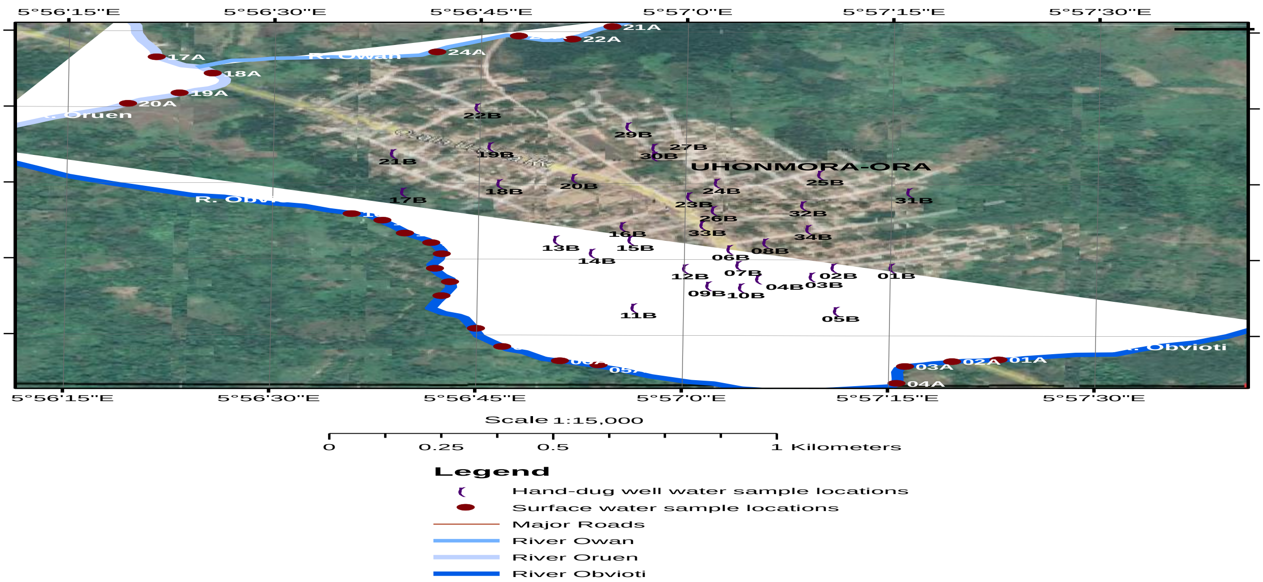


Figure 3: Sampling Location Imagery of the Rivers in Uhonmora - Ora.
Source: GIS and Cartography Unit, Kogi State University, Anyigba (2023).

Other materials used were a water cooler, ice blocks, water-sample-1-litre-plastic-cans, paper tape, pen, marker and writing material, electrical conductivity meters, compass, drilling soil auger, a geological hammer, hand lens, nose mask, polyethylene and sack-bags. Electrical conductivity meters, test-tube and glass-bottles (McCartney) reagents and test soil were also used for field measurements. Soil samples were digested and concentrations of elements were measured. The Atomic Absorption Spectrometer (Agilent 280, FSAA), and s. Mettler balance (FA2104), equipment was used to carry out the physicochemical analyses at the Laboratory of the Department of Chemistry, National Open University of Nigeria, Abuja. The equipment of thermostat incubator (Jenlab Medical Instrument USA Technology), laboratory incubator (DNP.9022A), bacteriological incubator (i-therm A1-7741), colony counter (J-2), top loading weighing balance, vortex mixer/shaker (SM-C), autoclave (YX-280A), refrigerator, sterilizing Petri boxes, bacteriological wire loop, petri dish disposal/glass, stacking rack, filter Duncan burners, conical flask and laminar flow chamber (SuGold) was used for the bacteriological analyses carried out at the Laboratory of the Department of Biological Sciences, National Open University of Nigeria, Abuja.

A total of 60 water samples were collected. These comprise 25 and 35 collections each from "A001 to A025" for surface (SU) and "B001 to B035" for groundwater (GW) sources respectively as presented in Fig 2. Water samples were collected between the hours of 6am and to 12noon each day, to test for physical parameters and filled into the 1-litre plastic containers, labelled and stored in the pack-of-ice-cooler for preservation. The samples tagged as 001(A and B), 002(A and B), and 003(A and B), to 025(A and B), for surface water and 001(A and B), 002(A and B), and 003(A and B) to 035(A and B), for groundwater sources respectively. A glimpse of water sampling collection for surface and groundwater sources were presented in Plates 1 and 2 and Table 1 respectively. Plate 1 shows the sampling of surface water collection at the study area, while Table 1 shows the sampling code and location of water samples collected from the eight quarters of the study.

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Plate1: Sampling of Surface Water Sources in the Study Area

Plate 2: Sampling of Groundwater Sources in the Study Area

Field Techniques for Sampled Collection

From the total of 60 water samples collected for analysis across the eight quarters in Uhonmora-Ora, a default total of eight were billed for collection per quarter (4 samples each per quarter for surface and groundwater sources). However, during the field exercise, the study was constrained by the non-presence of surface water sources in the Oduosi and Ukhuoro quarters as only four samples each were collected for both seasons as presented in Table 1. Thus, the increase of surface and groundwater samples from four to six in the Ukpokunmu quarter was due to the large size and geo-spread of the landmass which cut across the Ukpafekhai and Ukpafotisi quarters. Table 1 shows the sampling code and location of water samples collected from the eight quarters of the study.

Table 1: Sampling code and location of water samples collected from the eight quarters

S/N	Quarter and Sampling Code	Dry Season (March) 2023
1	Odosi (**ODO**)	**a. Hand-Dug Well: ODO-GW^2**/001A, **ODO-GW^2**/002A, **ODO-GW^2**/003A and **ODO-GW^2**/004A only
2	Ukpafoga (**UKP**)	**a. Hand-Dug Well: UKP-GW^2**/001A, **UKP-GW^2**/002A, **UKP-GW^2**/003A and **UKP-GW^2**/004A **b. Surface Water: UKP-SU^2**/001B, **UKP-SU^2**/002B, **UKP-SU^2**/003B, and **UKP-SU^2**/004B.
3	Ukhuedeodu (**ODU**)	**a. Hand-Dug Well: ODU-GW^2**/001A, **ODU-GW^2**/002A, **ODU-GW^2**/003A, and **ODU-GW^2**/004A **b. Surface Water: ODU-SU^2**/001B, **ODU-SU^2**/002B, **ODU-SU^2**/003B, and **ODU-SU^2**/004B.
4	Ukpafisi (**UFI**)	**a. Hand-Dug Well: UFI-GW^2**/001A, **UFI-GW^2**/002A, **UFI-GW^2**/003A, and **UFI-GW^2**/004A. **b. Surface Water: UFI-SU^2**/001B, **UFI-SU^2**/002B, **UFI-SU^2**/003B, and **UFI-SU^2**/004B.
5	Ukpokunmu (**UMU**)	**a. Hand-Dug Well: UMU-GW^2**/001A, **UMU-GW^2**/002A, **UMU-GW^2**/003A, **UMU-GW^2**/004A, **UMU-GW^2**/005B, and **UMU-GW^2**/006B. **b. Surface Water: UMU-SU^2**/001B, **UMU-SU^2**/002B, **UMU-SU^2**/003B, **UMU-SU^2**/004B, **UMU-SU^2**/005B, and **UMU-SU^2**/006B.
6	Ukpafekhai (**UAI**)	**a. Hand-Dug Well: UAI-GW^2**/001A, **UAI-GW^2**/002A, **UAI-GW^2**/003A, and **UAI-GW^2**/004A. **b. Surface Water: UAI-GW^2**/001B, **UAI-GW^2**/002B, **UAI-GW^2**/003B, and **UAI-SU^2**/004B.
7	Ukpafortisi (**USI**)	**a. Hand-Dug Well: USI-GW^2**/001A, **USI-GW^2**/002A, **USI-GW^2**/003A, **USI-GW^2**/004A. **b. Surface Water: USI-SU^2**/001B, **USI-SU^2**/002B, **USI-SU^2**/003B, and **USI-SU^2**/004B.
8	Ukhuoro (**URO**)	**a. Hand-Dug Well: URO-GW^2**/001A, **URO-GW^2**/002A, **URO-GW^2**/003A, and **URO-GW^2**/004A only.

Source: This Study, 2023

On the laboratory examination of chemical analyses of trace elements, the water samples were filtered into a 100-standard volumetric flask and 1 ml of nitric acid was added to free the ions and metals. The analysis was performed using the above equipment and technique at different wavelengths automatically selected by the instrument. On the other hand, the methods of the most probable number (MPN), and spread plate methods (SPM) were used for the examination of bacteriological analysis. Both the test analyses of physicochemical and bacteriological analyses were carried out in line with the recommended standards of the global practices on water regulatory body of the World Health Organization (WHO, 2018), as adopted by the National Standard Development Water Quality (NSDWQ, 2018), The descriptive statistical methods of Table illustrations as mean concentration (MC), correlation matrix (CM), and WHO Standards of Water Quality (WHSWQ), were adopted and used for the study. The correlation analysis was used to identify the mean concentration and correlations matrix of the synergy between surface and groundwater parameters. The results from the text of physicochemical and bacteriological parameters were analyzed with the aid of SPSS (IBM, 29), and inferential statistical methods, as presented with correlation matrix of Tables 2 to 12 respectively. In addition, was the used of Bivariate Correlation and ANOVA statistical analyses to analyze the collected data.

Results and Discussion

The results of the study were compressed, summarized and presented in Tables 2 to 12. Table 2 shows the comparison of the detected parameters from the surface and groundwater samples and a comparative study with the WHO (2018), standards on water quality with the detected variables in Uhonmora-Ora.

Table 2: Physical Parameters of Surface and Groundwater Sources in Uhonmora-Ora during the Dry Season.

Variable	SU Temp	GW Temp	SU NTU	GW NTU	SU DO	GW DO	SU TSS	GW TSS	SU pH	GW pH	SU EC	GW EC	SU TDS	GW TDS
WHO 2018	**36.1^{0}C**	**36.1^{0}C**	**5.0**	**5.0**	**3.0**	**3.0**	**200**	**200**	**8.5**	**8.5**	**1000**	**1000**	**500**	**500**
001	**28.5**	30.1	7.52	41.17	5.29	4.7466	25.0	35.0	**6.7**	5.4	0.02	0.15	21	115
002	28.5	30.1	6.09	70.168	5.05	3.7797	24.0	40.6	6.4	4.3	0.01	0.27	17	196
003	29.4	30.9	6.44	103.104	5.05	3.8676	26.1	53.6	6.4	4.4	0.01	0.41	18	288
004	28.6	29.9	6.80	95.586	5.05	5.3619	22.4	43.5	6.4	6.1	0.02	0.37	19	267
005	29.6	31.1	7.16	85.92	5.13	4.395	30.3	45.7	6.5	5.0	0.02	0.33	20	240
006	29.5	29.8	6.44	76.254	5.13	4.395	24.7	43.7	6.5	5.0	0.01	0.30	18	213
007	29.5	30.9	6.09	92.722	5.05	5.1861	24.0	61.7	6.4	5.9	0.01	0.36	17	259
008	29.1	31.6	6.09	95.944	5.05	4.395	26.8	63.5	6.4	5.0	0.01	0.38	17	268
009	27.2	30.7	6.44	340.816	5.13	5.5377	30.0	35.7	6.5	6.3	0.01	1.32	18	952
010	27.1	30.9	6.44	105.252	5.05	5.1861	30.2	36.3	6.4	5.9	0.01	0.41	18	294
011	27.1	30.3	7.88	151.076	5.05	5.0982	24.6	35.0	6.4	5.8	0.02	0.60	22	422
012	27.2	29.7	6.44	19.332	5.05	6.2409	25.8	40.6	6.4	7.1	0.01	0.76	18	54

013	28.1	29.3	6.80	163.964	5.21	5.3619	32.0	53.6	6.6	6.1	0.02	0.64	19	458
014	27.9	29.7	7.16	152.866	5.13	5.6256	32.8	43.5	6.5	6.4	0.02	0.60	20	427
015	28	29.4	0.01	182.938	5.05	5.7135	24.2	45.7	6.4	6.5	20	0.72	0.02	511
016	28.3	29.2	6.80	169.692	5.05	5.4498	25.8	43.7	6.4	6.2	0.01	0.66	19	474
017	29.1	30.6	7.52	131.028	5.37	5.6256	25.0	61.7	6.8	6.4	0.02	0.51	21	366
018	29.1	30.6	6.80	128.164	5.21	5.7135	24.0	63.5	6.6	6.5	0.01	0.50	19	358
019	28.6	30.6	6.80	57.996	5.13	5.1861	26.1	35.7	6.5	5.9	0.01	0.22	19	162
020	28.9	31	7.16	53.7	5.13	5.0103	22.4	36.3	6.5	5.7	0.02	0.20	20	150
021	28.7	31	6.80	111.338	5.05	5.274	30.3	35.0	6.4	6.0	0.02	0.44	19	311
022	28.7	30.8	6.80	14.678	4.97	4.395	24.7	54.3	6.3	5.00	0.01	0.1	19	41
023	28.6	31.3	6.80	65.872	4.97	5.0103	24.0	54.3	6.3	5.7	0.01	0.25	19	184
024	28.8	29.8	6.80	129.954	4.89	5.7135	25.0	54.2	6.2	6.5	0.01	0.51	19	363
025	28.8	30.7	5.37	24.702	5.13	4.6587	24.0	45.6	6.5	5.3	0.01	0.09	15	69
026	-	30.8	-	118.14	-	5.0103	-	43.2	-	5.7	-	0.46	-	330
027	-	29.9	-	251.316	-	5.274	-	45.3	-	6.0	-	0.98	-	702
028	-	30.8	-	148.212	-	5.4498	-	43.6	-	6.2	-	0.58	-	414
029	-	30.6	-	123.868	-	5.7135	-	42.7	-	6.5	-	0.48	-	346
030	-	29.4	-	103.104	-	5.5377	-	38.9	-	6.3	-	0.40	-	288
031	-	29.8	-	6812.024	-	6.2409	-	40.7	-	7.1	-	2.50	-	19028
032	-	29.8	-	83.056	-	5.6256	-	43.5	-	6.4	-	0.32	-	232
033	-	29.9	-	159.668	-	5.9772	-	45.6	-	6.8	-	0.63	-	446
034	-	29.5	-	248.094	-	5.8014	-	46.2	-	6.6	-	0.97	-	693
035	-	30.1	-	41.17	-	4.7466	-	45.8	-	5.4	-	0.15	-	115

Source: This Study, 2023

The results from Table 2 show the physical parameters of surface and groundwater sources in Uhonmora-Ora during the dry season. From the result, elevation was high in Ukpafoga (82), River Obvioti for surface water and much higher in Ukpafisi (103), in groundwater sources. A pH of 6.7 was recorded in River Obvioti at Ukpafoga (before human interaction) for surface water and 7.1 for groundwater sources from a new hand-dug well at Ukhuoro quarter. Furthermore, a TDS of 22 and EC of 20 were recorded in River Obvioti at Ukpokunmu due to human activities such as washing, bathing, pudding of cocoa and irrigation for surface sources and 19028.0 and 0.98 were recorded at Ukhuoro (from a new hand-dug well) and Ukpafekhai quarters respectively. In addition, a Turbidity of 7.52 and DO of 5.29 were recorded at Obvioti River surface water sources and 6812 at Ukhuoro (new hand-dug well). The count of 6.812 was tied at Ukhuoro (new hand-dug well) and Ukhuedeodu quarters for groundwater sources respectively. These findings are consistent with the summation of Strahler and Strahler (2006), Soladoye and Agbebaku, (2015), that physical parameters of surface and groundwater influence water sources. In addition, the indices of climatic variation, shared contaminants from pollutants, interactions and associations are other determined factors.

Table 3: Geochemistry of Surface and Groundwater Sources in Uhonmora-Ora During the Dry Season.

Variable	SU Iron (Fe)	GW Iron (Fe)	SU Cad. (Cd)	GW Cad. (Cd)	SU Cop. (Cu)	GW Cop. (Cu)	SU Cal. (Ca)	GW Cal. (Ca)	SU Mag (Ma)	GW Mag (Ma)	SU Lead (Pb)	GW Lead (Pb)	SU Zine (Zn)	GW Zine (Zn

WHO 2018	0.1	0.1	0.003	0.003	3.0 (2mg/L)	3.0 (2mg/L)	75	75	100–300 mg/litre,	100–300 mg/litre,	0.01	0.01	5.0	5.0
001	0.173	0.048	0	0.002	0	0.038	59.6	4.974	0.849	0.813	0.03	0.01	0.4689	0.46
002	0	0.156	0	0.002	0.018	0	38.1	6.707	6.3776	0.6984	0.03	0.01	0.4594	0.4677
003	0.058	0.198	0	0.002	0	0.01	5.335	4.864	12.0407	0.7021	0.06	0.02	0.4596	0.4699
004	0.355	0.145	0	0.002	0.057	0	38.5	5.012	4.36	13.7454	0.07	0.04	0.46	0.4824
005	0.14	0	0	0	0.038	0	58.6	39.1	15.9744	13.2272	0.05	0.04	0.4792	0.4608
006	0.048	0	0	0.002	0	0	5.207	25.2	18.3124	8.3672	0.06	0.05	0.4589	0.4666
007	0.156	0.123	0	0.001	0.01	0.035	5.015	23.2	0.5945	4.747	0.05	0.04	0.49	0.4631
008	0.198	0.047	0	0.002	0	0	4.735	14.554	14.971	9.1902	0.04	0.04	0.4599	0.454
009	0.145	0.1	0	0.002	0	0	43.9	22.7	23.2766	2.1966	0.04	0.03	0.4612	0.461
010	0	0.578	0	0.003	0	0	4.82	7.768	0.5757	0.849	0.01	0.03	0.4596	0.4617
011	0	0.43	0.001	0.002	0.035	0	21.4	6.12	0.4999	6.3776	0.01	0.06	0.4612	0.4614
012	0.123	0.318	0.001	0.003	0	0	5.124	25.6	0.4507	12.0407	0.01	0.07	0.4666	0.4666
013	0.047	0.267	0.001	0.003	0	0.012	0	30.7	14.085	4.36	0.01	0.05	0.4636	0.4604
014	0.1	0.207	0.002	0.003	0	0	4.14	6.66	0.6261	15.9744	0	0.06	0.4644	0.4604
015	0.578	0.259	0.002	0.004	0	0.033	27.1	59.6	6.424	18.3124	0.03	0.05	0.4603	0.4636
016	0.43	0.477	0.001	0.003	0	0	24.7	38.1	0.5089	0.5945	0.01	0.04	0.4712	0.4689
017	0.318	0.199	0.002	0.004	0.012	0	5.425	5.335	13.7095	14.971	0.02	0.04	0.4599	0.4594
018	0.267	0.105	0.002	0.003	0	0.024	77.4	38.5	0	23.2766	0.03	0.01	0.4625	0.4596
019	0.207	0	0.002	0.003	0.033	0.005	5.387	58.6	8.082	0.5757	0.04	0.01	0.4596	0.46
020	0.259	0	0.002	0.002	0	0.028	10.737	5.207	8.6049	0.4999	0.02	0.01	0.4873	0.4792
021	0.477	0.069	0	0.004	0	0	4.25	5.015	0.4946	0.4507	0.04	0.01	0.4627	0.4589
022	0.199	0.114	0.002	0.007	0.024	0	41.4	4.735	26.3013	14.085	0.04	0	0.4649	0.49
023	0.105	0.075	0.001	0.004	0.005	0	5.647	43.9	0.589	0.6261	0.05	0.03	0.467	0.4599
024	0	0.297	0.002	0.003	0.028	0	25.3	4.82	0.849	6.424	0.05	0.01	0.4613	0.4612
025	0	0.332	0.002	0.002	0	0	5.108	21.4	6.3776	0.5089	0.03	0.02	0.4648	0.4596
026	-	0.354	-	0.004	-	0	-	5.124	-	13.7095	-	0.03	-	0.4612
027	-	0.213	-	0.003	-	0.032	-	0	-	0	-	0.04	-	0.4666
028	-	0.24	-	0.003	-	0	-	4.14	-	8.082	-	0.02	-	0.4636
029	-	0.536	-	0.003	-	0	-	27.1	-	8.6049	-	0.04	-	0.4644
030	-	0.187	-	0.004	-	0	-	24.7	-	0.4946	-	0.04	-	0.46
031	-	0.021	-	0.004	-	0	-	5.425	-	26.3013	-	0.05	-	0.4677
032	-	0.564	-	0.004	-	0	-	77.4	-	0.589	-	0.05	-	0.4699
033	-	0.265	-	0.004	-	0.041	-	5.387	-	8.6075	-	0.03	-	0.4824
034	-	0.313	-	0.007	-	0.011	-	10.737	-	0.0628	-	0.03	-	0.4608
035	-	0.313	-	0	-	0.007	-	4.25	-	9.0266	-	0.01	-	0.4666

Source: This Study, 2023

The results from Table 3 showed that the highest concentration of Fe(0.477), was recorded at Ukpafisi for surface water sources while 0.578 was recorded at Ukhuedeodu quarters for groundwater sources. The highest value for Cd(0.002), was tied in most of the quarters of the community for surface water sources while 0.007 was recorded at Ukpohunmu quarters for groundwater sources. Furthermore, the highest value for Cu(0.057), was recorded at Ukpafoga for surface water sources while 0.041 was recorded at Ukhuoro quarters for groundwater sources. The highest value for Ca(59.6), was recorded at Ukpafoga for surface water sources while 14.554 was recorded at Ukhuedeodu quarters for groundwater sources. The highest value for Ma(26.3013), was recorded at Ukpafortisi for surface water sources and the same value was recorded at Ukpafekhai quarters respectively for groundwater sources. The highest value for Pb(0.07), was recorded at Ukpafoga quarters for both surface and groundwater sources respectively. While the highest value for Zn(0.4792), was recorded at Ukhuedeodu for both surface and groundwater sources respectively. These findings are consistent with the summation of Soladoye and Agbebaku, (2015) and Agbebaku, Raleigh and Afolayan (2022), that there is geochemistry of surface and groundwater sources during the dry season. In addition, the indices of climatic variation, shared contaminants from pollutants, interactions and associations are other determined factors.

Table 4: Descriptive and Mean Concentration Analysis of Geochemistry of the Surface Water Sources during the Dry Season.

Variables	Mean	Min.	Max.	S.D.	C.V.
Turbidity (NTU)	6.458	0.01	7.88	49.98	22.35
DO	5.094	4.97	5.29	0.1	1.98
TSS	26.168	26.17	24	2.96	11.31
Ph	6.456	6.3	6.8	0.13	1.95
EC	0.813	0.01	20	4	491.55
TDS	18.04	0.02	21	4.03	22.35
Fe	0.175	0	0.578	0.16	90.5
Cd	0.04	0	0.002	0	98.83
Cu	0.010	0	0.057	0.02	155.24
Ca	21.065	0	77.4	21.71	102.98
Ma	7.397	0	26.3013	7.9	106.74
Pb	0.033	0	0.07	0.02	56.16
Zn	0.465	0.46	0.4873	0.01	1.8

Source: This Study, 2023

Table 4 shows the mean concentration of the examined parameters of the physical and geochemistry of the surface water quality during the dry season in Uhonmora-Ora. From the Table, Turbidity, DO, TSS and TDS concentrations were much lower in surface water than in groundwater sources (Table 5). The Ph appears higher in surface water than in groundwater sources. The concentration of EC was higher in groundwater sources (Table 5) and in-between in the Min. and Max. for surface water sources. From the Table, a lot of variations exist within and among the geochemistry of surface water quality during the dry season. This could be a result of the settling of the concentration of shared contaminants and climatic variations of surface water sources during the dry season. The mean concentrations of Fe, Cd, Cu, Ca, Ma, Pb and Zn were in the combination of static and in-between surface water sources during the dry season in Uhonmora-Ora.

Table 5: Descriptive and Mean Concentration Analysis of Geochemistry of the Groundwater Sources during the Dry Season.

Variables	Mean	Min.	Max.	S.D.	C.V.
Turbidity (NTU)	307.225	19.322	6812.024	1133.91	369.08
DO	5.2087	3.7797	6.2409	0.6	11.57
TSS	45.642	45.63	35	8.36	18.32
Ph	5.925	4.3	7.1	0.69	11.57
EC	0.530	0.1	2.50	0.43	81.37
TDS	858.171	41	19028	3167.34	369.08
Fe	0.215	0	0.578	0.16	76.34
Cd	0.003	0	0.007	0	49.3
Cu	0.007	0	0.0.41	0.01	169.66
Ca	19.218	0	14.554	19.07	99.22
Ma	9.963	0	26.3013	7.18	100.9
Pb	0.032	0	0.07	0.02	55.07
Zn	0.465	0.46	0.4824	0.01	1.66

Source: This Study, 2023

Table 5 shows the mean concentration of the examined parameters of the physical and geochemistry of the groundwater quality during the dry season in Uhonmora-Ora. From the Table, Turbidity, DO, TSS and TDS concentrations were much higher in the groundwater sources than in surface water. The concentration of Ph appears higher in groundwater sources than in surface water sources. The concentration of EC was lower in groundwater sources than in surface water sources. The mean concentrations of Fe, Cd, Cu, Ca, Ma, Pb and Zn were in the combination of static and in-between surface and groundwater sources during the dry season in Uhonmora-Ora. From the Table, a lot of variations exist within and among the geochemistry of surface and groundwater quality during the dry season. This could be a result of the settling of the concentration of shared contaminants of groundwater sources during the dry season as against the wet season. It is worthy of note from the Analysis of Variance, that the result shows that there is no significant difference between surface and groundwater quality during the dry season in Uhonmora-Ora. The reasons for these are attributed to lithology, the concentrations and the influence of shared contaminants and seepages of surface and groundwater sources. Other factors could be the movement, recharge and discharge of surface and groundwater sources. These findings are consistent with the summation of Strahler and Strahler (2006), and Soladoye and Agbebaku, (2015).

Table 6: Analysis of Variance of the Physical Parameters of Surface and Groundwater Sources

ANOVA

Physical Parameters of Surface and Groundwater Sources		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
a. Surface Water Sources	Between Groups	1575.77	1	313.289	2.003E3	.000
	Within Groups	262.62	24	.146		
	Total	**1848.89**	**25**			
b. Groundwater Sources	Between Groups	13059.02	1	27.044	1.009E3	.000
	Within Groups	2176.503	34	.046		
	Total	**15235.505**	**35**			

Source: This Study, 2023

The results from the Table show ANOVA analysis of the sum of squares and mean square of the physical parameters for (a)surface water sources Between Groups were 1575.77 and 313.289 respectively and Within Groups were 262.62 and .146 respectively. (b)groundwater sources Between Groups were 13059.02 and 27.044 respectively and Within Groups were 2176.503 and .046 respectively. Therefore, the result shows that there is a significant difference between surface and groundwater quality during the dry season in Uhonmora-Ora. These findings are consistent with the summation of Chapman. (1996) and Strahler and Strahler (2006), that the rate of concentration of shared contaminants of surface and groundwater sources is usually higher during the dry season than in the wet season.

Table 7: Analysis of Variance of the Geochemical of Surface and Groundwater Sources

ANOVA

Geochemical of Surface and Groundwater Sources		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
a. Surface Water Sources	Between Groups	728.9944	1	243.289	1.013E3	.000
	Within Groups	104.1420	24	.146		
	Total	**833.1364**	**25**			
b. Groundwater Sources	Between Groups	947.0617	1	17.041	1.089E3	.000
	Within Groups	135.0617	34	.046		
	Total	**1082.3562**	**35**			

Source: This Study, 2023

The results from the Table show ANOVA analysis of the sum of squares and mean square of the geochemistry for (a)surface water sources Between Groups were 728.9944 and 259.229 respectively and Within Groups were 104.1420 and .146 respectively. (b)groundwater sources Between Groups were 947.0617 and 17.041 respectively and Within Groups were 135.0617 and .046 respectively. Therefore, the result shows that there is a significant difference between surface and groundwater sources during the dry season in Uhonmora-Ora. These findings are consistent with the summation of Chapman. (1996), Strahler and Strahler (2006), Agbebaku,

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Raleigh and Afolayan (2022), that the rate of concentration of shared contaminants of surface and groundwater sources is usually higher during the dry season than in the wet season.

Table 8: Rate of Isolation of Bacteria Counts from Surface(SU) and Groundwater(GW) Sources in Uhonmora-Ora during the Study.

	Isolates Rate, Number (%)									
Quarter	***K. pneumoniae***		***E. coli***		***S. typhi***		***E. aerogenes***		**Total**	
Samples	**SU**	**GW**	**SU**	**GW**	**SU**	**GW**	**SU**	**GW**	**SU**	**GW**
Odosi (n=4)	0(0)	2(50)	0(0)	2(50)	0(0)	2(25)	0(0)	2(50)	0(0.00)	8(13.85)
Ukhuoro (n=4)	0(0)	2(50)	0(0)	2(50)	0(0)	1(25)	0(0)	3(75)	0(0.00)	8(21.42)
Ukpafoga (n=4)	1(75)	2(50)	2(50)	3(75)	1(25)	1(25)	2(20)	2(50)	6(21.14)	8(14.29)
Ukhuedeodu (n=4)	2(10)	2(25)	1(0)	2(25)	1(25)	1(0)	0(0)	3(75)	4(08.67)	8(21.42)
Ukpafisi (n=4)	1(25)	0(0)	1(25)	2(50)	1(25)	1(25)	2(50)	0(0)	5(14.20)	3(5.36)
Ukpokunmu (n=6)	2(25)	4(50)	3(75)	3(50)	2(50)	2(33)	2(50)	3(50)	9(20.86)	12(19.64)
Ukpafekhai (n=4)	1(25)	2(25)	2(20)	2(50)	2(25)	0(0)	2(50)	2(50)	7(20.00)	6(8.93)
Ukpafortisi (n=4)	1(25)	1(25)	2(50)	2(50)	1(0)	0(0)	1(25)	2(50)	5(11.43)	5(8.93)
Control (n=2)	1(25)	0(0)	0(0)	2(50)	0(0)	1(25)	1(25)	1(25)	2(05.70)	4(7.14)
Total	**9(23.33)**	**15(18.33)**	**11(31.43)**	**20(22.05)**	**8(18.75)**	**9(17.55)**	**10(20.00)**	**18(32.14)**	**38(10.0)**	**63(100.8)**

Key: n number of samples N= number of isolates %= Percentage. *Klebsiella pneumonia, Escherichia coli, Salmonella typhi, Enterobacter aerogenes*

Source: This Study, 2023.

Table 8 shows the rate of isolation of bacteria counts from surface(SU) and groundwater(GW) sources in Uhonmora-Ora during the study. From the Table, the counts of bacteriological parameters of K. pneumoniae, E. coli, S. typhi and E. aerogenes vary from quarter to quarter between surface and groundwater sources and are relatively low from the control point, in-between and variance in surface and groundwater sources as compared with the WHO (2018), recommended standards limit on water quality in the study. These findings are consistent with the summation of Chapman (1996), Strahler and Strahler (2006), Chukwu and Oranu (2018), Agbebaku, Raleigh and Afolayan (2022), that shared contaminants from pollutants, seepages, interactions and associations during the season are determined factors for the sources of surface and groundwater pollution.

Table 9: Distribution of Bacteria Isolates from Surface(SU) and Groundwater(GW) Sources across the eight Quarters in Uhonmora-Ora during the Study

Sample Location	Number of Bacterial Isolates		Percentages (%)	
	SU	**GW**	**SU**	**GW**
Odosi	2	2	0.00	13.85
Ukhuoro	2	2	0.00	21.42
Ukpafoga	3	6	20.04	14.29
Ukhuedeodu	3	4	08.67	21.42
Ukpafisi	3	4	14.20	03.36
Ukpokunmu	8	8	20.86	19.64
Ukpafekhai	2	5	20.00	08.93
Ukpafortisi	2	4	11.13	08.95
Control	1	1	05.70	04.14
Total	**26-1**	**36-1**	**100**	**100**

Key: n= number of samples N= number of isolates %= Percentage

Table 10: Frequency of Occurrence of Bacteria Isolates from Surface(SU) and Groundwater(GW) Sources across the eight Quarters in Uhonmora-Ora during the Study

Sample Location	Occurrence Frequency		Percentages (%)	
	SU	**GW**	**SU**	**GW**
K. pneumoniae	5	8	18.14	21.43
E. coli	8	10	31.43	35.71
S. typhi	7	6	22.86	11.73
E. aerogenes	*2*	11	27.57	31.13
Total	**25**	**35**	**100**	**100**

Key: n= number of samples N= number of isolates %= Percentage

Table 10 shows the frequency of occurrence of bacteria isolates from surface(SU) and groundwater(GW) Sources across the eight quarters in Uhonmora-Ora during the study. From the Table, the concentration of *E. coli* accounted for the highest (8), followed by S. tyhi (7), *K.* pneumoniae (5) and E. aerogenes (2), for surface water sources. While the concentration of aerogenes (11), accounted for the highest counts. This was followed by *E.* coli (10), *K.* pneumoniae (8) and S. tyhi (6), for groundwater sources respectively. These findings are consistent with the summation of Strahler and Strahler (2006), Chukwu and Oranu (2018), Agbebaku, Raleigh and Afolayan (2022), that shared contaminants from pollutants, seepages, interactions and associations during the season are determined factors for the occurrence of bacteria isolates of surface and groundwater pollution.

Table 11: Correlation Matrix of the Physio-Chemical Parameters and Biological Counts in Uhonmora-Ora Surface Water**.**

	T	DO	TSS	Ph	EC	TDS	Fe	Cd	Cu	Ca	Ma	Pb	Zn	K. Pneumo	E. Coli	S. Typhi	E. Aerog
T	0																
DO	-0.335**	0															
TSS	0.658**	-0.421*	0														
Ph	0.059	0.567**	0.350	0													
EC	0.218	0.172	0.212	0.503**	0												
TDS	0.320	0.161	0.209	0.540**	0.661*	0											
Fe	0.213	0.027	0.155	0.355	0.451**	0.627**	0										
Cd	0.217	0.225	0.168	0.502**	0.573**	0.821**	0.437	0									
Cu	0.239	0.214	0.124	0.504**	0.973**	0.936**	0.625**	0.972*	0								
Ca	0.170	0.366*	0.118	0.568**	0.897**	0.859**	0.512**	0.924**	0.934**	0							
Ma	0.352*	0.072	0.250	0.535**	0.930**	0.868**	0.561**	0.937**	0.915**	0.873**	0						
Pb	0.324	-0.028	0.265	0.453*	0.819**	0.823**	0.789**	0.719**	0.764**	0.632**	0.731**	0					
Zn	0.425*	-0.058	0.257	0.333*	0.812**	0.841**	0.609**	0.782**	0.650**	0.606**	0.636**	0.835**	0				
K	0.600**	-0.031	0.340	0.369**	0.821**	0.830**	0.521**	0.768**	0.753**	0.625**	0.737**	0.802**	0.959**	0			
E	0.647	0.755	0.665	0.506*	0.568**	0.345**	0.778**	0.647**	0.637**	0.694**	0.619**	0.747**	0.937**	0.462**	0		
S	0.965	0.947*	0.617	0.708*	0.623**	0.618**	0.654**	0.624**	0.615**	0.626**	0.937**	0.528**	0.512**	0.513**	0.523**	0	
E	0.759	0.546	0.443	0.548	0.723*	0.546	0.638**	0.625**	0.514**	0.524**	0.523**	0.540**	0.531**	0.503**	0.515**	0.456**	0

Source: This Study, 2023
*Significant @ 0.05 **Significant @ 0.01

Table 11 shows the correlation matrix of the physiochemical parameters and biological counts in the Uhonmora-Ora surface water of the study. The comparative analyses of the examined variables of surface water quality were discussed with a correlation matrix of the physiochemical parameters and biological counts in Uhonmora-Ora groundwater sources in detail in Table 12.

Table 12: Correlation Matrix of the Physico-Chemical Parameters and Biological Counts in Uhonmora-Ora Groundwater Sources.

	T	DO	TSS	Ph	EC	TDS	Fe	Cd	Cu	Ca	Ma	Pb	Zn	K. Pneumo	E. Coli	S. Typhi	E. Aerog
T	0																
DO	-0.355**	0															
TSS	0.968**	-0.451*	0														
Ph	0.060	0.587**	0.151	0													
EC	0.320	0.182	0.214	0.703**	0												
TDS	0.425	0.171	0.333	0.580**	0.981*	0											
Fe	0.416	0.037	0.158	0.475	0.681**	0.697**	0										
Cd	0.367	0.245	0.168	0.692**	0.963**	0.971**	0.477	0									
Cu	0.359	0.234	0.154	0.604**	0.987**	0.939**	0.645**	0.982*	0								

Ca	0.270	0.369*	0.218	0.668**	0.897**	0.959**	0.612**	0.928**	0.934**	0							
Ma	0.472*	0.079	0.270	0.645**	0.958**	0.898**	0.576**	0.987**	0.965**	0.873**	0						
Pb	0.364	-0.038	0.288	0.463*	0.859**	0.845**	0.799**	0.739**	0.786**	0.637**	0.754**	0					
Zn	0.458*	-0.058	0.277	0.365*	0.837**	0.857**	0.609**	0.755**	0.752**	0.628**	0.738**	0.845**	0				
K	0.505**	-0.039	0.370	0.489**	0.891**	0.880**	0.524**	0.788**	0.769**	0.755**	0.767**	0.802**	0.969**	0			
E	0.667	0.685	0.775	0.586*	0.738**	0.445**	0.688**	0.667**	0.587**	0.678**	0.659**	0.577**	0.977**	0.477**	0		
S	0.865	0.967*	0.657	0.768*	0.623**	0.648**	0.676**	0.646**	0.646**	0.658**	0.997**	0.578**	0.536**	0.543**	0.563**	0	
E	0.489	0.556	0.455	0.578	0.553*	0.567	0.678**	0.645**	0.564**	0.548**	0.563**	0.546**	0.554**	0.543**	0.465**	0.466**	0

*Significant @ 0.05 **Significant @ 0.01

The results from Tables 11 and 12 showed the correlation matrixes of the comparative analyses of the physiochemical parameters and biological counts for surface and groundwater sources from the examined variables. From the Tables, it was obvious that TSS has no relationship with other parameters thus, a very positive and perfect relationship exists between the physicochemical parameters and bacteriological counts for both surface and groundwater sources. It was also observed, that there is a very high and positive correlation between Turbidity and TSS (r = 0.658) of surface and groundwater (r = 0.968). This implies that the higher the concentration of TSS, the more the water turbidity owing to the shared contaminants from interactions and associations from surface and groundwater sources. In addition, a very high and positive correlation exists between EC and Ph (r = 0.503), for surface and (r = 0.703) for groundwater, TDS and Ph (r = 0. 540), for surface and (r = 0. 580) for groundwater, Cd and Ph (r = 0.502), Cu (r = 0.504), Ca (r = 0.568), Ma (r = 0.535) and K (r = 0.369), for surface water sources, and Cd (r = 0.692), Cu (r = 0.604), Ca (r = 0.668), Ma (r = 0.645), and K (r = 0.489), for groundwater respectively. Perfect and high correlation occurred between Fe and TDS (r = 0.627), Cd^-(r = 0.821), Cu (r = 0.936), Ca (r = 0.859), Ma (r = 0.868), Pb (r = 0. 845), Zn (r = 0. 857), K (r = 0. 830), E (r = 0. 345), and S (r = 0.618), surface water sources, and Fe (r = 0.697), Cd^-(r = 0.971), Cu (r = 0.939), Ca (r = 0.959), Ma (r = 0.898), Pb (r = 0. 843), Zn (r = 0. 857), K (r = 0. 880), S (r = 0. 345), and S (r = 0.648), for groundwater sources respectively.

Furthermore, very high and positive correlations exist between Cd, Cu, Ca, Ma, Pb and Zn for surface and groundwater sources respectively as presented in the Tables. In addition, the results from Table 12, revealed that there was a very high and positive correlation exists among the counts of EC and Fe (r = 0.451), EC and Cd (r = 0.537), EC and Cu (r = 0.973), EC and Ca (r = 0.897), EC and Ma (r = 0.930), EC and Pb (r = 0.819), and EC and Zn (r = 0.812), respectively for surface water sources. EC and Fe (r = 0.681), E and Cd (r = 0.963), EC and Cu (r = 0.897), EC and Ca (r = 0.958), EC and Ma (r = 0.959), EC and Pb (r = 0.463), and EC and Zn (r =

0.837), for groundwater sources. But a very high correlation occurred for S and TDS (r = 0.618)/(r = 0.648) EC (r = 0.654), Fe (r = 0.633)/ (r = 0.676), Cd (r = 0.624)/ (r = 0.646), Ca (r = 0.618)/(r = 0.685), Ma (r = 0.618)/(r = 0.997), Pb (r = 0.528)/(r = 0.578)/, Zn (r = 0.512)/(r = 0.536), while the like of K (r = 0.513)/(r = 0.543), and E (r = 0.523)/(r = 0.563), respectively for surface and groundwater sources where got from biological counts. The high correlation of these counts could be a result of seasonality, climatic variation, shared contaminants from pollutants, interactions and associations of these parameters and counts which conformed with the studies of Akoteyon and Soladoyin (2011), Soladoye and Agbebaku (2015), Agbebaku (2020) and Agbebaku et al (2023). Factors such as the land use pattern and habitat conditions for the micro-organisms to thrive in groundwater could be added factors to their correlations and this summation also conformed to the WHO (2018), permissive limit for water quality.

Conclusion and Recommendations

The study examined the geochemistry of surface and groundwater sources during the dry season in Uhonmora-Ora. There exists some level of shared contaminants from anthropogenic and natural sources on contamination, interactions and associations of surface and groundwater sources. The study shows there is not much difference between the observed and detected parameters of physicochemical and bacteriological counts between the surface and groundwater sources in Uhonmora-Ora. The study revealed a very positive and perfect relationship between the physicochemical parameters and biological counts for surface and groundwater sources. The high correlation of these concentrations during the dry season could be a result of the combination of; climatic variation, shared contaminants from pollutants, interactions and associations of these parameters.

In essence, the geochemistry shows the variance of results, that a very high and positive correction, perfect and high correlation and high and positive correlation exist between and among the texted parameters. Furthermore, variations exist within and among the mean concentration of NTU, DO, TSS, TDS, Fe, Cd, Cu, Ca, Ma, Pb, Zn, K, E, S and E were in-between surface and groundwater sources. The results of geochemistry show there is no significant difference between surface and groundwater sources. The influence of lithology, shared contaminants, and movement of recharge and discharge which is a bit higher in the dry season further influence the processes. The study also revealed that the rate of shared contaminants of surface and groundwater sources is higher during the dry season than in the wet season. The study recommends there should be urgent measures for quality sources of water in Uhonmora-Ora. These measures will help to improve human health and conserve human stress and cost implications of getting quality drinking water.

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