CONFERENCE PROCEEDING
International Conference on Developmental Sciences and Technologies, Federal University of Agriculture, Abeokuta, Nigeria. 27 – 30 August, 2019. https://unaab.edu.ng/2020/06/colphysproceedings/

Effect of Cassava Effluent Migration (in Cassava Miller Processing) on Groundwater within Ilaro Southwestern Nigeria

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Abstract

Investigation of groundwater contamination due to cassava effluent movement which was investigated from vulnerable cassava processing system was delineated using geochemical method. The study area was situated within the geographic latitude 6º 52´9.6˝ to 6º 54´49˝ N and geographic longitude 003º 01´36.2˝ E to 003º 00´42.4˝ E which is within the sedimentary formation of Dahomey Basin South western Nigeria The study was aimed to evaluate the groundwater contamination and extent due to cassava effluent filtration from proximate hand dug wells flanking the study area for intake purposes via qualitative and quantitative methodology. A total number of fifteen (15) parameters were studied using nineteen groundwater samples collected. The water samples were collected and analysed for different physicochemical properties. The result of the physicochemical analysis showed that the water samples obtained in the study area are acidic, with mean pH value of 6.18. The mean values of EC, TDS, TH, Ca, Mg, Zn, Mn, Cu, Cl^-, HCO_3^-, SO_4^{2-} , NO_3^- , Na^+ and K^+ are 143.47, 73.53, 65.26, 3.68, 0.40, 0.14, 0.07, 0.01, 19.11, 183.0, 0.4305, 0.6632, 27.66 and 5.34 respectively, which falls within standard limits of WHO. The result of the water quality using index approach on the water samples were the range of 14.633 and 29.000 which falls in the excellent and good category. This reveals the fitness and suitability of the water sources for drinking and domestic purposes. The groundwater samples are within the harmless (safe) limits of these parameters will neither cause salinity threat nor have slightly antagonistic influence on the soil properties, thus making it appropriate for irrigation purpose.

Keywords: Groundwater, Cassava effluent, Physico-chemical Analysis and Groundwater quality index

1. Introduction

Water serves as an essential part of biological existence of human beings because is the solvent that transports many essential molecules and other particles around the body, such that water is regarded as liquid of life because human existence is not possible without water. (Mukesh *et al.*, 2014). Water quality made up of physical, chemical, and biological qualities of groundwater like pH, temperature, hardness, TDS, heavy metals, coliform and E.coli. This research is to evaluate the groundwater contamination due to cassava effluent filtration from proximate hand dug wells flanking the study area for drinking via qualitative and quantitative methodology.

Groundwater Quality Index (GWQI) is an efficient tool used for assessments that reflects the effect of different water quality parameters and classifying the suitability of water resource for drinking and domestic purposes. It indicates the overall quality of waters in terms of a single value at a certain location and time based on several water quality parameters (Saeedi *et al.*, 2010). It is important to note that water is used for various purposes ranging from domestic, agricultural, industrial and several human activities . Water is obtained from different sources such as pipe-borne water, hand-dug wells, borehole, streams and spring. The study area has large cassava miller in from which the improper disposal of cassava effluent are improperly released to the environment, resulting to percolation in the soil and later migrating into the groundwater aquifers.

2. Description of the Study Area

The study was conducted in in Ilaro Ogun State, South west Nigeria, Ilaro, which is the headquarters of Yewa South Local Government Area of Ogun State, Nigeria, is situated on Geographic latitude 6º 52´9.6˝ N to 6º 54´49˝ N, and longitude 003º 01´36.2 E to 003º 00´42.4˝ E. The climate condition was classified as Aw by Koppen and Geiger (2007), with an average temperature of 26.9°C and mean precipitation of 1257 mm. which is one of the many sedimentary formations in the Dahomey basin which overlies the Oshosun formation. Its neighbouring towns include, Ajilete, Oke-Odan Owode, Ibese, Oja Odan, Pahayi, Idogo-Ipaja, Papa-Alanto, and Imasayi, The Geological map of Ogun State Nigeria with Study Area is shown in figure 1.

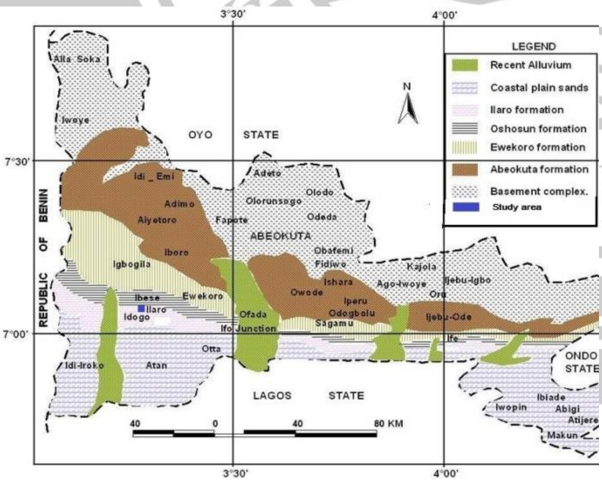

Figure 1: Geological Map of Ogun State Nigeria showing the study area (After NGSA, 2009)

3. Materials and Methods

Sample Collection

Water samples were collected randomly from hand-dug well within the study area and its environs A total of nineteen (19) water samples labelled W1 to W19 were collected in 75cl bottles from hand-dug wells and boreholes for the purpose analysis in order to determine some selected physical parameters: (pH value, TDS, EC and Total Hardness), chemical parameters (Ca, Mg, Cl^-, HCO_3^-, SO_4^{2-} , NO_3^- , Na^+, K^+ and heavy metals (Zn, Mn, and Cu). These containers were washed thoroughly with distilled water and dried before being filled with water samples. The containers were numbered serially, along with proper record of sample location. The plastics bottles were rinsed three times each with the water. The geographic coordinate of the sampling points were taken on the field with the aid of hand-held Garmin GPS as shown in Table 1. The physical properties of the samples were analysed using a Coulomb multimeter at the Water Quality Analysis Laboratory at the College of Environment and Resource Management (COLERM) FUNAAB, Ogun State. The chemical properties were analysed using AAS at Federal University of Agriculture Abeokuta (FUNNAB) Central Laboratory and SMO laboratory Ibadan, Oyo State.

Table 1: Geographical coordinates of the sample points

S/N	Samples	Latitude	Longitude	Elevation
1	W1	115m	N 06˚54´30.5 ˝	E 003˚00´45.4˝
2	W2	111m	N 06˚54´30.8 ˝	E 003˚00´44.2˝
3	W3	109m	N 06˚54´31.4 ˝	E 003˚00´42.6˝
4	W4	110m	N 06˚54´32.7 ˝	E 003˚00´42.8˝
5	W5	106m	N 06˚54´33.1 ˝	E 003˚00´43.7˝
6	W6	110m	N 06˚54´31.1 ˝	E 003˚00´43.0˝
7	W7	39m	N 06˚52´10.4 ˝	E 003˚00´52.2˝
8	W8	49m	N 06˚52´15.1 ˝	E 003˚00´49.3˝
9	W9	37m	N 06˚52´14.6 ˝	E 003˚00´47.7˝
10	W10	36m	N 06˚52´13.9 ˝	E 003˚00´47.8˝
11	W11	45m	N 06˚52´18.0 ˝	E 003˚00´38.8˝
12	W12	45m	N 06˚52´18.5 ˝	E 003˚00´37.4˝
13	W13	41m	N 06˚52´19.4 ˝	E 003˚00´33.0˝
14	W14	42m	N 06˚52´03.7 ˝	E 003˚00´51.0˝
15	W15	41m	N 06˚52´07.8 ˝	E 003˚00´44.1˝
16	W16	42m	N 06˚52´10.0 ˝	E 003˚00´40.1˝
17	W17	40m	N 06˚52´10.8 ˝	E 003˚00´36.6˝
18	W18	43m	N 06˚52´09.0 ˝	E 003˚00´37.4˝
19	W19	43m	N 06˚54´08.2 ˝	E 003˚00´37.7˝

Table 2 shows the physical properties of the analysed water samples; the pH which is the measure of the intensity of acidity or alkalinity and the concentration of free hydrogen (H+) and hydroxyl (OH-) ions in the water, pH values have an estimated values of 4.60-7.65 with an average of 6.18. This implies that most water samples in the areas were acidic and also fall below the limit range between 6.5 and 8.5 recommended by WHO (2017) standard of limit for drinking water, Electrical conductivity (EC) is a measure of the capacity of water to conduct electric current. Prakash and Somashekar (2006) had observed that groundwater tends to have high EC when compared to the surface water because of the presence of high amount of dissolved salts. The electrical conductivity has a unit denoted as **µScm^{-1}**. Electrical conductivity (EC) results show the water samples range between 27 and 626 **µScm^{-1}** with average value of 327**µScm^{-1}**. **T**his **i**mplies low conductivity and low mineralization; however, the high value of conductivity could be as a result of high concentration of ion constituents in the water. The water samples in the areas also fall within the recommended limit of WHO Standard limit for drinking water, which is 1000 µScm^{-1}.

Table 2: Physical parameters of groundwater of fufu processing sites around Ilaro

WATER SAMPLES	PH VALUE	ELECTRICAL CONDUCTIVITY**(EC)(µScm^{-1})**	TOTAL DISOLVED SOLIDS (TDS) **(mg/L)**	HARDNESS **(mg/L)**
W1	6.08	36.00	18.00	12.00
W2	5.86	88.00	42.00	20.00
W3	6.34	62.00	31.00	46.00
W4	6.40	27.00	15.00	44.00
W5	5.99	38.00	20.00	78.00
W6	6.08	57.00	28.00	54.00
W7	5.97	626.00	332.00	86.00
W8	5.81	78.00	38.00	54.00
W9	5.91	70.00	35.00	24.00
W10	6.09	80.00	44.00	24.00
W11	4.60	171.00	86.00	60.00
W12	5.33	153.00	74.00	78.00
W13	6.41	362.00	181.00	110.00
W14	6.05	66.00	34.00	58.00
W15	6.33	85.00	42.00	72.00
W16	7.37	175.00	101.00	102.00
W17	7.65	200.00	101.00	102.00
W18	7.37	252.00	125.00	102.00
W19	5.84	100.00	50.00	114.00
WHO (2017) Limits	**6.5-8.5**	**1000**	**500**	**120**

Ttotal hardness, which is the measure of the level of carbonates, bicarbonate, fluorides and Sulphate of Calcium and magnesium present in water; it can also be a measure of variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations dissolved in water. The lowest and highest values of Total hardness were recorded in W1, with 12 mg/L and W19 with 114 mg/L respectively; the values lie below the value of 150 mg/L, which is the standard limit recommended by WHO (2017) for drinking water. Total Hardness classification by Sawyer and McCarthy (1967) showed the ranges of Soft water (0-75mg/l), moderately hard water (75-150mg/l), hard water (150-300mg/l) and very hard water (>300mg/l). From this classification, it was observed that all the water samples are within soft and moderately hard water.

The TDS results in those areas show a minimum value of TDS was observed in water sample W4 with value of 15mg/L; maximum value was observed in water sample W7 with value of 332 mg/L; these values are within the maximum permissible limit value of 500 mg/L for TDS, as recommended by WHO (2017). High TDS contents could be attributed to the release of contaminants into the underground water which is mainly of carbonates, bicarbonates, chlorides, Phosphates, and nitrates of Calcium, Magnesium, Sodium, Potassium and manganese, organic matter, salt and other particles (Mahananda *et al*., 2010). According to Davis and De Wiest (1966) classification of water based on TDS value, water below 1000mg/l are classified fresh water; this implies the water in the investigated study area can be classified as fresh water. According to WHO (2017) the permissible limit TDS in drinking water is 500mg/L, thus the TDS analyses in the water samples around the area under consideration reveals that the water is save for drinking purposes

Table 3 shows the result of chemical properties of the water samples analysed; this includes Calcium (Ca) whose minimum value of 2.0028 mg/L was observed in W7 and W19 maximum Value of 8.0795 mg/L in W19, with an average value of 5.0412mg/L. The permissible limits according to WHO Standard of drinking water is 75 mg/L, this implies that all the water samples analysed fell within the limit. Magnesium (Mg) has its maximum permissible limit by WHO Standard for drinking water to be 50 mg/L; the value ranges of the water sampled in the area has a minimum value of 0.095 mg/L in W1 and maximum value of 1.4107 mg/L in W18. However the Magnesium contents in the sampled water is low and fall within the maximum permissible limits. Zinc has minimum and maximum concentration values of 0.0254 mg/L and 0.2918mg/L respectively, observed in W4 and W19. The maximum WHO permissible limit of Zinc in drinking water is 3mg/L. Although these values for Zinc were 100% Compliance with WHO (2017). The recommended maximum permissible values by WHO (2017) for drinking water for Manganese is 50mg/L, From the results it was observed that Manganese falls within the maximum standard recommended by WHO (2017) for drinking water, Manganese was not detected in 42% of the water samples analysed as shown in Table 3.

The anions, which are the negative ions (-ve), and cations, which are the positive (+ve) ions were analysed in the water samples of the investigated area; these are shown in Table 4. Chlorine in groundwater and surface are naturally occurring in deep aquifers or caused by pollution from sea water, brine, or industrial or domestic wastes. The result of water samples analysed showed the minimum and maximum values to be 8.00mg/L and 60.00 mg/L, found in W1 and W13 respectively. The maximum WHO (2017) permissible limit is 250mg/L, this implies that the water samples analysed fall below the WHO permissible Standard limit for drinking water.

Nitrate (NO_3^-) is found naturally in the environment, it is an important plant nutrient with varying concentrations in all plants, and it is a part of the nitrogen cycle. The WHO limits for drinking water recommended 50 mg/l, the range of the water samples are between 0.34 mg/L and 1.130 mg/L in W12 and W16 respectively but fall below the permissible limits for the drinking purposes.

Table 3: Chemical parameters of groundwater of fufu processing site around Ilaro

WATER SAMPLES	Ca **(mg/L)**	Mg **(mg/L)**	Zn **(mg/L)**	Mn **(mg/L)**
W1	2.1852	0.1941	0.1363	0.0592
W2	3.0058	0.0953	0.1630	N/D
W3	2.3242	0.1551	0.1466	0.1720
W4	3.4177	0.3789	0.0254	0.3350
W5	3.8530	0.3772	0.1364	0.1190
W6	3.0549	0.2559	0.1340	0.1266
W7	3.9041	0.3037	0.2233	0.1656
W8	3.4748	0.1967	0.1331	0.0784
W9	3.7342	0.2282	0.1616	N/D
W10	2.0028	0.0553	0.0889	N/D
W11	3.9012	0.2786	0.1894	0.0729
W12	3.1076	0.3027	0.1555	0.0148
W13	2.7388	0.2275	0.1348	0.1319
W14	3.1410	0.2209	0.1050	N/D
W15	2.5162	0.1685	0.1092	N/D
W16	3.2352	0.4314	0.1068	N/D
W17	8.0795	1.0681	0.1222	N/D
W18	5.9981	1.4107	0.1059	N/D
W19	6.1778	1.3109	0.2918	0.0522
WHO (2017) Limits	**75**	**50**	**3.00**	**0.4**

This implies the water samples were not contaminated from wastewater disposal, oxidation of nitrogenous waste products in human and other animal excreta, including septic tanks. Bicarbonate (HCO_3^-) result of water samples analysed in those locations ranges between 61 and 732 mg/L in W4 and W11 with maximum permissible limit by WHO (2017) is 1000 mg/L. This implies the water samples analysed are below the permissible limit of WHO Standard for drinking water, only W13 had a value of 0.00mg/L which implies no trace of Bicarbonate (Hco_3^-) and Sulphate (SO_4^{2-}) water sample analysed for sulphate had a range between 0.00 to 1.050 mg/l with the minimum in W2 and maximum in W6. Thus, the water samples analysed fall with the maximum permissible limit of 250mg/L recommended by WHO for drinking water, however 50% of water samples analysed had values of 0.00mg/L. that is no trace of SO_4^{2-}

The cations includes Sodium ion (Na^+) and Potassium ion, (K+). Sodium is a soft, silvery-white, highly reactive metal that is never found in nature in the un-combined state. The sodium ion (Na^+) is ubiquitous in water. Saline intrusion, mineral deposits, seawater spray, sewage effluents, and salt used in road de-icing can all contribute significant quantities of sodium to water. The result of water samples analysed in the location ranges between 18.5228 mg/L and 48.1654 mg/L in W10 and W19 as minimum and maximum values respectively. The maximum permissible limit by WHO (2017) is 200mg/L. This implies the water samples analysed are within the permissible limit of WHO standard of drinking water. Potassium is an essential element in humans and is seldom, if ever, found in drinking water at levels that could be a concern for healthy humans. Although concentrations of potassium normally found in drinking-water are generally low and do not pose health concerns, the high solubility of potassium chloride and its use in treatment devices such as water softeners can lead to significantly increased exposure. The result of Potassium ion, (K+) of water samples analysed in the investigated area ranges between 3.0891mg/L and 13.9647 mg/L in W10 and W19 respectively. The maximum permissible limit by WHO (2017) for drinking water is 30mg/L.

This implies the water samples analysed are within the permissible limit of WHO (2017) standard for drinking water.

Groundwater Quality Analysis

Groundwater quality index (GWQI) approach is an important tool which was used to analyse the water samples in which 11 parameters which included pH, TH, Ca^{2+}, Na^+, K^+, HCO_3^-,Cl^-, TDS, SO_4^{2-}, NO_3^- and Mg^{2+} were considered. Samples were assigned a weight (w_i) according to their relative essence in the overall water quality for drinking purpose. Nitrate was assigned maximum weight of 5 due to its major essence in water quality assessment; the weight of other parameters varied from 2-5 depending on their significant essence in water quality determination. The relative weight for each parameter (Ramakrishnaiah *et al.,* 2009) is shown in Table 5

In the second step, the relative weight (W_i) was computed from the equation 1

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad 1$$

Where W_i is the relative weight, w_i is the weight of each parameter and n is number of parameters estimated.

The quality scale q_i was evaluated for each chemical parameter using equation 2

$$q_i = \left(\frac{C_i}{S_i}\right) \times 100 \qquad 2$$

where q_i is the quality rating, C_i is the concentration of each chemical parameters in each of the collected water sample and S_i is the World Health Organization WHO (2017) drinking permissible standard for each of the selected chemical parameters.

To compute GWQI of the water samples, the sub index of the *i*th parameter is the calculated using equation 3

Table 4: Anions and Cations of groundwater of fufu processing site around Ilaro

WATER SAMPLE	Cl^- (mg/L)	Hco^-_3 (mg/L)	SO_4^{2-}(mg/L)	NO_3^-(mg/L)	Na^+ (mg/L)	K^+ (mg/L)
W1	8.00	183.00	0.4300	1.0700	18.5228	3.4884
W2	13.00	183.00	0.0000	0.3900	22.1480	5.0608
W3	16.00	305.00	0.0000	0.9100	19.6773	3.4840
W4	13.00	61.00	0.0000	0.3000	35.8133	6.6805
W5	15.00	122.00	0.5300	0.5100	36.6885	7.3519
W6	10.00	183.00	1.0500	0.4600	20.8735	4.4969
W7	19.00	427.00	0.1100	0.4600	31.1464	4.6012
W8	17.00	122.00	0.0000	0.6200	26.9729	3.7017
W9	14.00	61.00	0.0000	0.7800	26.5080	4.5206
W10	11.00	61.00	0.0000	0.3900	22.8974	3.0891
W11	28.00	732.00	0.7400	0.9200	27.3745	4.7350
W12	22.00	183.00	0.0000	1.1300	27.0428	3.5861
W13	60.00	0.00	0.3200	0.8600	23.0779	2.9405
W14	14.00	61.00	0.0000	1.0400	30.7094	3.8825
W15	18.00	183.00	0.0000	0.9500	20.7353	3.2500
W16	21.00	427.00	0.5300	0.3400	33.4802	9.2529
W17	21.00	61.00	3.6200	0.3800	29.6516	7.5938
W18	24.00	61.00	0.0000	0.3600	23.9703	5.7394
W19	19.00	61.00	0.8500	0.7300	48.1654	13.9647
WHO (2017) Limits	250	1000	250	50	200	30

Table 5: Relative weight for each parameter (Ramakrishnaiah *et al.,* 2009*)*

Parameters	**S_d (2007)**	**W_i**	$Wi = \frac{wi}{\sum_{1-l}^{n} SI_d}$
pH	6.5-8.5		
		4	0.121
TH	150	2	0.061
Ca^{2+}	75	2	0.061
Mg^{2+}	50	2	0.061
Na	200	2	0.061
K^+	55	2	0.061
HCO_3^-	1000	3	0.091
Cl^-	250	3	0.091
TDS	500	4	0.121
NO_3^-	50	5	0.152
SO_4^{2-}	250	4	0.121
Total		$\sum wi = 33$	$\sum wi =$ 1.002

$$SI_i = W_i q_i \quad 3$$

GWQI can therefore be estimated by summing up sub index of all parameters using equation 4

$$GWQI = \sum_{i-1}^{n} SI_i \quad 4$$

Based on GWQI value, quality of water was assessed using the water quality index scale (Mishra and Pacel, 2001). This is shown in Table 6.

Table 6: Water quality classification based on WQI Value (Mishra and Pacel, 2001)

WQI	Water quality
0-25	Excellent
26-50	Good
51-75	Fair
76-100	Poor
100 and ab	Unfit for drink

The determination of groundwater quality index with reference to the suitability of groundwater for human consumption was taken into considered in this study using World Health Organization WHO (2017) guidelines standards for drinking water.
The groundwater quality index value for the individual water samples are presented in Table 7, with ranges between 14.633 and 29.000. Based on groundwater quality classification by Mishra and Pacel (2001), Table 6 shows, from the calculated value of GWQI that 100% of water samples analysed are excellent, good and considered fit for human consumption.

Table 7: Water Quality Index Classifications

Samp	WQI Val	Remark
W 1	14.633	Excellent
W 2	15.705	Excellent
W 3	18.468	Excellent
W 4	16.819	Excellent
W 5	18.923	Excellent
W 6	17.282	Excellent
W 7	29.000	Good
W 8	16.838	Excellent
W 9	14.963	Excellent
W 10	14.680	Excellent
W 11	22.697	Excellent
W 12	19.008	Excellent
W13	24.327	Excellent
W14	16.921	Excellent
W15	19.017	Excellent
W16	27.517	Good
W17	24.817	Excellent
W18	24.196	Excellent
W19	22.908	Excellent

4. Conclusion

The purpose of this study is to evaluate the extent of groundwater contamination due to cassava effluent filtration from Cassava processing site into proximate hand dug wells flanking the study area for drinking via qualitative and quantitative methodology. The

Parame	S_d (2007)	W_i	$Wi = \frac{wi}{\sum_{1-i}^{n} SI_d}$
pH	6.5-8.5	4	0.121
TH	150	2	0.061
Ca^{2+}	75	2	0.061
Mg^{2+}	50	2	0.061
Na	200	2	0.061
K^{+}	55	2	0.061
HCO_3^-	1000	3	0.091
Cl^-	250	3	0.091
TDS	500	4	0.121
NO_3^-	50	5	0.152
SO_4^{2-}	250	4	0.121
Total		$\sum wi = 33$	$\sum wi =$ 1.002

obtained result revealed that the physical and chemical properties of the water samples collected and analysed from those proximate hand dug well falls within the maximum permissible WHO (2017) limits for drinking water. The index approaches also revealed that 100% of the water samples are within the "excellent and good" category according to water quality classification by Mishra and Pacel, (2001). It was concluded that water source are considered fit and suitable for drinking and domestic purposes.

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