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Seasonal Variations of Shallow Well Water Quality in Amuwo-Odofin and Ojo LGA's of Lagos, Nigeria

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Water from fifteen shallow wells used for irrigation was analysed during the wet and dry seasons of 2012 and 2013 respectively from Amuwo-Odofin and Ojo LGAs in Lagos-Nigeria. *In situ* parameters were measured for electrical conductivity, pH and total dissolved solids using portable metres. Bicarbonate, calcium, carbonate, and chloride were determined using a titrimetry method. Magnesium, potassium and sodium were determined with an Atomic Absorption Spectrophotometer while sulphate was determined using a spectrophotometer. Total hardness was computed using Fournier equation. The study aimed at examining the seasonal variations of shallow well water for irrigation purpose in the study area. Data were analysed using tables, charts, descriptive inferential statistics and irrigation water quality indices. The results show that the mean values of all the parameters were higher in dry season compared to the wet season except for pH. The paired samples T-test indicate significant seasonal variations at $p<0.05$ for sodium, potassium, bicarbonate and sulphate. The Kelly ratio, magnesium ratio, residual sodium carbonate, percentage sodium and sodium adsorption ratio indices have revealed that the water quality is suitable for irrigation in both seasons. The spatial pattern of sodium and salinity hazard shows that all the samples are suitable for irrigation except for locations G_{12} and $G_{14;}$ and G_9 in dry and wet seasons respectively. It was concluded that the shallow well water is suitable for irrigation. Routine monitoring, appropriate treatment and investigation of soil quality test are recommended for further study.

Keywords: *irrigation; salinity hazard; seasonal variations; shallow well; sodium hazard; water quality index*

1. Introduction

Water is required for meeting several needs for human, fauna and flora species. The water requirement for meeting these various needs should not only be in sufficient quantity, but should be of good quality in order not to cause any harmful effects on the lives (Garg, 2010). Most crops require certain quantity and quality of water for optimum growth. Globally, groundwater serves as a major resource for the livelihoods and food security of about 1.2 to 1.5 billion rural households in the poorest regions of Africa and Asia (Comprehensive Assessment of Water Management in Agriculture, 2007). It is estimated that the about 3,600 cubic kilometres per year of groundwater is globally withdrawn for various uses. Irrigation of agricultural lands accounted for about 70% of the water used globally (World Water Assessment Programme (WWAP, 2006; Vineesha & Singh, 2008). For example, in Asia, the Middle East, North Africa and sub-Saharan Africa irrigation accounts for almost 85–90% of all withdrawals (WWAP, 2012). Although irrigation is essential for food security, it has been reported that irrigation of agricultural lands is responsible for surface and groundwater quality deterioration due to pesticides, pollutants, nutrients, sediments and salinisation among others (WWAP, 2006).

In addition, raw water used for irrigation contains certain impurities, such as salts and minerals that are harmful for human as well as for plant growth. Thus, irrigation water management is vital for irrigation crop cultivation. The suitability of water for irrigation depends on several factors, such as soil type, crop selection, climatic conditions, irrigation methods adopted, drainage conditions of the area, fertiliser use, farm management practices and irrigation supplies (Hussain *et al.*, 2010). Several irrigation water quality schemes have been proposed by many authors. Some of these classification schemes are based on two or more factors, usually total salinity and relative amount of sodium (Hussain *et al.*, 2010). For instance, the US salinity Laboratory (1954) classification scheme that rates water with respect to total salinity (EC) and sodium hazard and sodium adsorption ration (SAR) has been widely used.

Wilcox (1948) highlighted four factors affecting the irrigation water quality, namely; salinity, sodium, boron and sodium carbonate. This classification scheme classifies salinity hazard (C) into four sub-zones, such as low salinity hazard (C1, <250 μS/cm), medium-salinity hazard (C2, 250 to 750 μS/cm), high-salinity hazard (C3, 750 to 2,250 μS/cm) and very-high-salinity hazard (C4, >2,250 μS/cm), representing good, moderate, poor and very poor water classes respectively. Similarly, sodium hazard (S) is categorised into four sub-zones, such as low-sodium hazard (S1, <10), medium-sodium hazard (S2, 10 to 18), high-sodium hazard (S3, 18 to 26) and very-high sodium hazard (S4, >26), representing good, moderate, poor and very poor irrigation water quality respectively. Doneen (1954) proposed a classification scheme based on effective salinity expressed in meq/L^{-1}.The effective salinity is defined as the total salinity less that of $CaCO_3$, Ca $(HCO3)_2$, $MgCO_3$, Mg $(HCO3)_2$ and $CaSO_4$ subtract in that order (Hussain *et al.,* 2010). Also, Doneen (1964) proposed a method of classifying irrigation water quality using permeability index (PI), Szaboles & Darab (1964) adopted magnesium hazard for evaluating irrigation water quality. Eaton (1950) applied Residual Sodium Carbonate (RSC) index Wilcox (1948), classified groundwater based on percentage of sodium upon the constituents of soil to be irrigated (Gupta & Gupta, 2008). Christiansen and Olsen (1973) proposed seven factors necessary for irrigation quality assessment to include electrical conductivity, sodium percentage, SAR, Na_2CO_3, CO_3, chloride, effective salinity and boron. The study aimed at examining the seasonal variations of shallow well water quality in Amuwo-Odofin and Ojo LGAS of Lagos-Nigeria uses water quality indices.

2. Materials and Methods

2.1. The study area

The study areas are located within Amuwo-Odofin and Ojo Local Government Areas (LGAs). Amuwo-Odofin Local Government Area (LGA) is located approximately on Latitudes $6^0$29’N and $6^0$27’N; Longitudes $3^0$14’W and $3^0$12’W. It is bounded by Ajeromi/Ifelodun LGA in the East, Isolo to the North, the Badagry Creek to the South and Ojo LGA in the West. The area occupies about 134.6 km^2 of land (Fig.1). The population is about 318.166 people (NPC, 2006). Unlike Ojo LGA, it is located approximately on Latitudes $4^0$15’N and $4^0$17’N; Longitudes $2^0$55’W and $2^0$12’W. It is bounded by Surulere LGA in the East, Apapa to the North, Eti-Osa to the South and Badagry LGA in the West. The area occupies about 134.6 km^2 of land with a population of about 598, 0 71 people (NPC, 2006) (Fig.1).

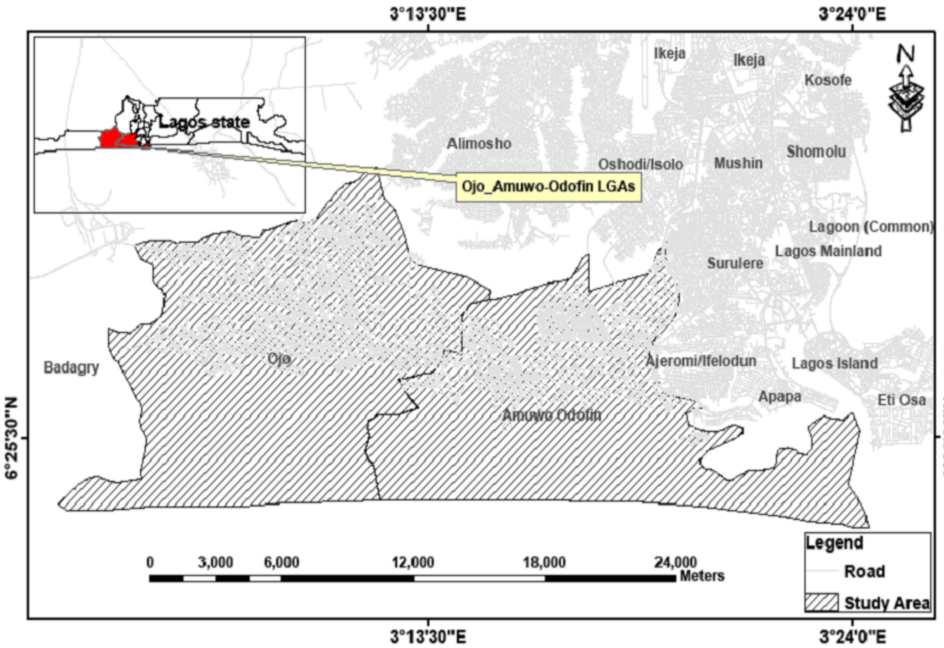

Fig. 1. Study area

The two major seasons recognised in the area are: dry season (between November and March) and wet season (April to October) with a short break in mid- August. The average temperature is about 27^0C with annual average rainfall of about 1.532 mm (Adetoyinbo & Babatunde, 2010). The dominant vegetation type consists of tropical swamp forest (fresh waters and mangrove swamp forests and dry lowland rain forest) (FEPA, 1997).

The drainage system is characterised by Lagoons and waterways, barrier islands and sand beaches. The major River is the Yewa River. The geology is underlain by recent sedimentary rock composed mainly of alluvial materials (Longe, 2011). A major human activity in the area includes farming, fishing, trading among others. Around Abule-Ado, Finniger, Okokomaiko and also along Lasu-Isheri road around post service and Lagos State University (LASU), the major farming activity is urban market gardening (Odumosu, 1999). Major crops planted include vegetables and lettuce, while other crops include garbage, onions, spinach etc. The major source of irrigation water is from shallow wells.

2.2. Data collection

Fifteen shallow wells used for irrigation representing nine samples from Amuwo-Odofin (G_{1-9}) and six samples from the Ojo (G_{10-15}) Local Government Areas (LGAs) were randomly selected for the irrigation water quality assessment during the wet season of July, 2012 and dry season March, 2013. Samples were stored in clean 1.5 litre polyethylene plastic bottles after being rinsed with the shallow well water to be sampled and were analysed at the chemistry department, University of Lagos. Samples were analysed using standard methods (APHA, 1998). *In situ* parameters were measured for electrical conductivity (EC), pH and total dissolved solids (TDS) using portable hand held meters (EC Dist 3 (HI98303, Hanna model), (PH-102, RoHS model) and TDS/TEMP HM digital model respectively. Bicarbonate (HCO_3), calcium (Ca), carbonate (CO_3), and chloride (Cl) were determined using a titrimetry method. Magnesium (Mg), potassium (K), and sodium (Na) were determined by Atomic Absorption Spectrophotometer (AAS), HI 98180 model while sulphate (SO_4) was determined using a spectrophotometer, HACH DR/2000 model. Total hardness was computed using the formula given by Fournier (1981) in Equation 1.

$$TH=2.5\ Ca\ (mg/L) + 4.1\ Mg\ (mg/L) \qquad (1)$$

Water quality indices including Kelly Ratio (KR), Magnesium Ratio (MR), Sodium percentage (%Na), Residual sodium carbonate (RSC) and Sodium absorption ratio (SAR) were employed for the irrigation water quality assessment given in Equations 2 to 6.

- Kelly (1963) expressed KR (Kelly's ratio) as:

$$\mathrm{KR} = \mathrm{Na}/\mathrm{Ca} + \mathrm{Mg} \qquad (2)$$

- Szaboles and Darab (1964) expressed MH (magnesium hazard) as:

$$\mathrm{MH} = \mathrm{Mg}/(\mathrm{Ca} + \mathrm{Mg}) \times 100 \qquad (3)$$

- Todd (1995) expressed %Na (Percent sodium) as:

$$\%\mathrm{Na} = \mathrm{Na} + \mathrm{K}/(\mathrm{Ca} + \mathrm{Mg} + \mathrm{Na} + \mathrm{K}) \times 100 \qquad (4)$$

- Eaton (1950) expressed RSC (residual sodium carbonate) as:

$$\mathrm{RSC} = (\mathrm{CO3} + \mathrm{HCO3}) - (\mathrm{Ca} + \mathrm{Mg}) \qquad (5)$$

- Richards (1954) expressed SAR (sodium adsorption ratio) as:

$$\mathrm{SAR} = (\mathrm{Na}/\sqrt{(\mathrm{Ca} + \mathrm{Mg})}\ /2 \ \text{ in meq /L} \qquad (6)$$

where:

Na - sodium, Ca - calcium, Mg -magnesium, K - potassium, CO_3 - carbonate, HCO_3 –bicarbonate.

All the ionic concentrations are in milliequivalents per litre (meq/L^{-1}).

Sodium hazard (SAR) and salinity hazard (Conductivity) were mapped using Wilcox plot also known as the U.S Department of Agriculture (USDA) (1954) while the co-ordinates of the sample locations were recorded using the Global Positioning System (GPS) and plotted using Arc Map 9.3 (Figs 2 and 3).The descriptive and inferential statistics (i.e. paired samples T-test - when measurement is in pair wise) were employed in analysing the results of shallow well water quality.

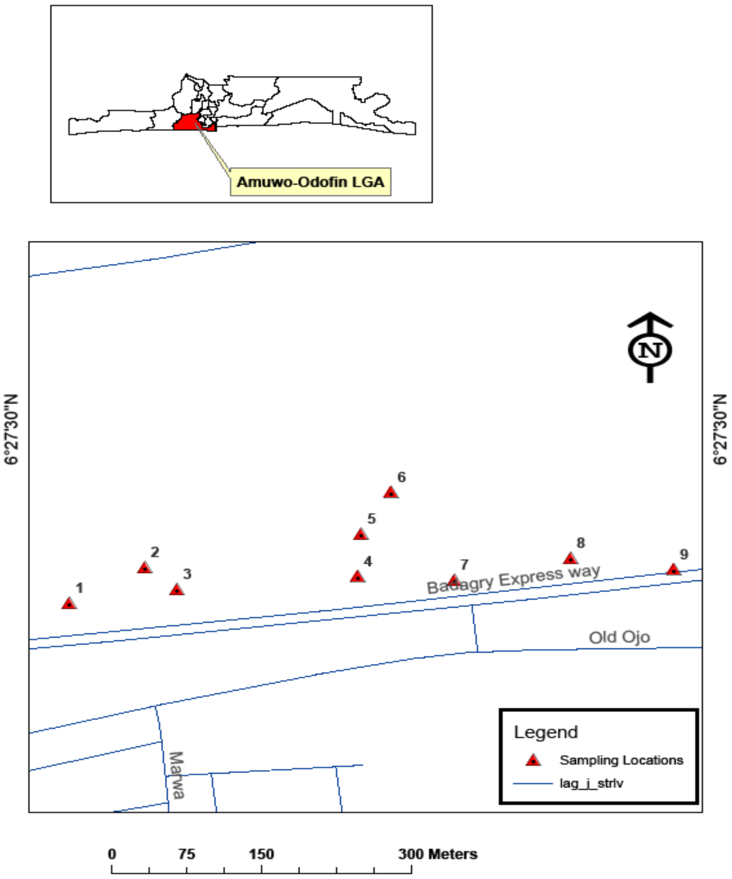

Fig. 2. Sampling locations (Amuwo-Odofin LGA)

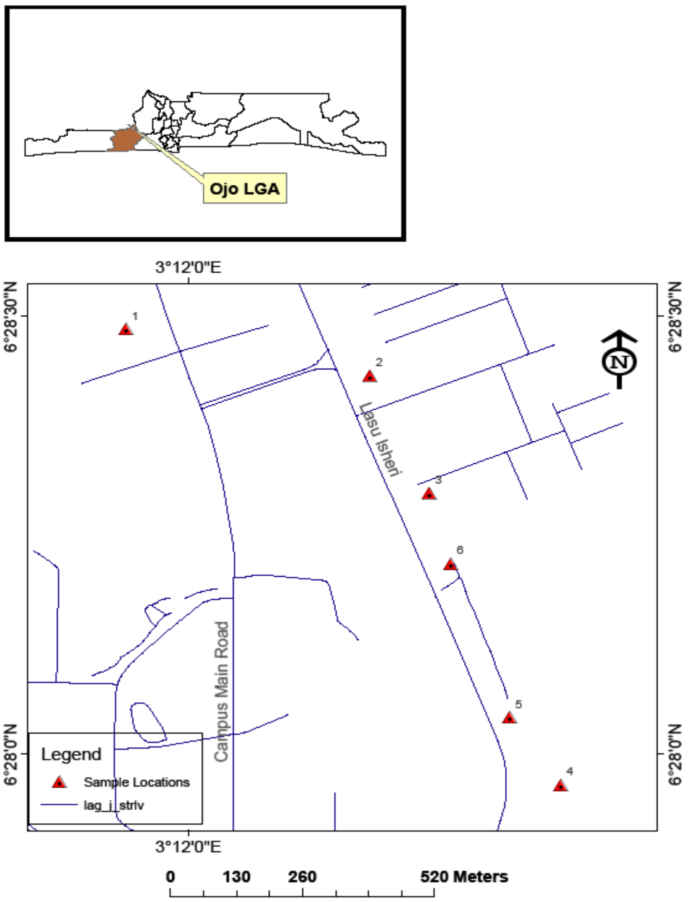

Fig. 3. Sampling locations (Ojo LGA)

3. Results and Discussion

The seasonal paired samples (measurement in pair wise) and correlation statistics of shallow well water are presented in Table 1. The results show that the mean and SD of pH, EC and TDS for dry and wet seasons are in the order of (7.28, 7.45 ± 0.21, 0.17; 535.53, 302.89 ± 179.23, 192.52 and 351.67, 202.39 ± 123.04, 129.01 respectively. The mean and SD values of major cations (Ca, Mg, Na and K) for dry and wet seasons are in the order of 41.6, 36.8 ± 11.76, 17.2; 13.2, 12.8 ± 4.95, 5.12; 26.61, 3.98 ± 7.83, 3.04 and 4.32, 1.7 ± 1.25, 1.08 respectively. The seasonal mean and SD values of major anions (HCO_3, SO_4, CO_3 and Cl) were found to be in the order of 7.6, 3.8 ± 2.53, 1.42; 17.93, 8.4 ± 8.64, 4.26; 10.8, 11.2 ± 2.48, 2.81 and 36.93, 30.13 ± 13.56, 11.58 respectively. With the exception of pH, the mean values of all the parameters were higher in dry season compared to the wet season in the study area (Table 1). The relationship among the examined parameters indicates that there are no significant correlations among the examined parameters for both seasons (Table 1).

Table 1. Seasonal paired sample statistics of shallow well water parameters

No	Parameters	Mean	N	Standard deviation	Correlation (r)	p-value
Pair 1	pH	7.28	15	0.21	-0.065	0.818
	pH*	7.45	15	0.17	-	-
Pair 2	EC	535.53	15	179.23	-0.344	0.209
	EC*	302.89	15	192.52	-	-
Pair 3	TDS	351.67	15	123.04	-0.354	0.196
	TDS*	202.39	15	129.01	-	-
Pair 4	Ca	41.60	15	11.76	-0.408	0.131
	Ca*	36.80	15	17.20	-	-
Pair 5	Mg	13.20	15	4.95	-0.470	0.077
	Mg*	12.80	15	5.12	-	-
Pair 6	Na	26.61	15	7.83	-0.313	0.255
	Na*	3.98	15	3.04	-	-
Pair 7	K	4.32	15	1.25	-0.375	0.168
	K*	1.70	15	1.08	-	-
Pair 8	HCO_3	7.60	15	2.53	-0.301	0.275
	HCO_3*	3.80	15	1.42	-	-
Pair 9	SO_4	17.93	15	8.64	-0.434	0.106
	SO_4*	8.40	15	4.26	-	-
Pair 10	CO_3	10.80	15	2.48	-0.352	0.198
	CO_3*	11.20	15	2.81	-	-
Pair 11	Cl	36.93	15	13.56	-0.330	0.229
	Cl*	30.13	15	11.58	-	-

Comments: wet season parameters are in asterisk

Table 2 presents the seasonal paired sample T-test of shallow well water parameters. The result shows that there are significant seasonal variations at $p < 0.05$ for four parameters, namely Na, K, HCO_3 and SO_4 in the study area (Table 2).

Table 2. Seasonal paired sample T-test of shallow well parameters

No	Parameters	Paired Differences					t	df	p–value
		Mean	Standard deviation	Standard Error Mean	Lower	Upper			
Pair 1	pH - pH*	-0.171	0.275	0.071	-0.323	-0.019	-2.417	14	0.030
Pair 2	EC - EC*	232.647	304.846	78.711	63.829	401.465	2.956	14	0.010
Pair 3	TDS - TDS*	149.273	207.395	53.549	34.422	264.125	2.788	14	0.015
Pair 4	Ca - Ca*	4.800	24.481	6.321	-8.757	18.357	0.759	14	0.460
Pair 5	Mg - Mg*	0.400	8.626	2.227	-4.377	5.177	0.180	14	0.860
Pair 6	Na - Na*	22.632	9.240	2.386	17.515	27.749	9.486	14	0.000
Pair 7	K - K*	2.616	1.930	0.498	1.547	3.685	5.248	14	0.000
Pair 8	HCO_3 - HCO_3*	3.800	3.256	0.841	1.997	5.603	4.520	14	0.000
Pair 9	SO4 - SO4*	9.533	11.167	2.883	3.349	15.717	3.306	14	0.005
Pair 10	CO_3 - CO_3*	-0.400	4.356	1.125	-2.812	2.012	-0.356	14	0.727

No	Parameters	Paired Differences					t	df	p–value
Pair 11	Cl - Cl*	6.800	20.533	5.302	-4.571	18.171	1.283	14	0.220

Comments: wet season parameters are in asterisk

Irrigation Water Quality Assessment. Various methods have been used for irrigation water quality assessment the world over. Some of the criteria include TDS, EC, relative proportion of sodium to other cations expressed as SAR, concentration of certain elements e.g. Na, Cl, B, and RSC (Sakar & Hassan, 2006). The results of the computed KR index for wet season ranged from 0.029-0.117meq/L with a mean value of 0.057 meq/L while it ranged from 0.312-0.484meq/L with a mean value of 0.368meq/L in the dry season value (Table 3).

The mean value of KR shows that about 40% and 33.3% of the sampling locations exceeded the KR index for dry and wet seasons respectively (Fig.4).

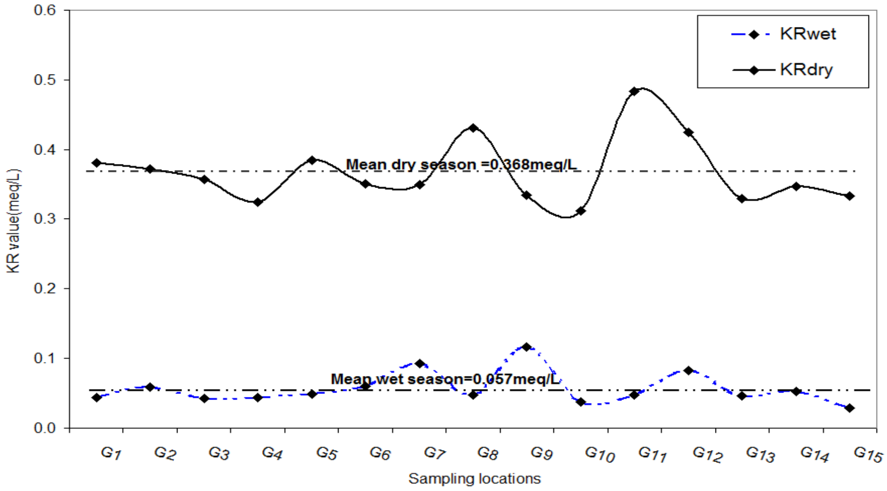

Fig. 4. Computed KR versus mean value

Kelly (1963) suggested that irrigation water quality should not exceed 1.0meq/L. Based on the KR index, all the shallow wells are suitable for irrigation in the study area. MR, RSC, %Na and SAR ranged from 29.191-43.211,-4.382 to -0.662, 3.379-11.958 and 0.053- 0.497 with a corresponding mean value of 37.438,-2.636, 6.583 and 0.193 respectively in the wet season. The values of the dry season show that, MR, RSC, %Na and SAR ranged from 26.818-45.194,-5.027 to -0.93, 25.664-34.716 and 0.69- 1.643 with a corresponding mean value of 33.682,-2.852, 28.64 and 1.289 respectively. About 60% of the mean value of the sampling locations exceeded the computed MR index for both seasons (Fig.5). Similarly, all the samples were found to be suitable for irrigation in both seasons since the MR index was less than 50meq/L (Szabolcs and Darab, 1964) (Table 3).

Table 3. Seasonal computed irrigation water quality indices

Code	Wet season				SAR	Code	Dry season				SAR
	KR	MR	RSC	%Na			KR	MR	RSC	%Na	
G1	0.044	33.100	-2.746	5.525	0.151	G1	0.381	34.544	-3.474	29.351	1.486
G2	0.059	35.473	-1.622	7.124	0.161	G2	0.372	27.264	-2.650	29.076	1.290
G3	0.042	37.796	-2.713	5.137	0.147	G3	0.357	34.240	-2.614	28.165	1.212
G4	0.044	40.183	-4.263	5.545	0.185	G4	0.324	34.422	-3.077	26.276	1.182
G5	0.049	42.835	-1.621	6.058	0.135	G5	0.385	45.194	-3.468	29.466	1.466
G6	0.060	32.376	-4.382	6.917	0.258	G6	0.351	30.079	-2.849	27.852	1.270
G7	0.093	38.803	-3.902	10.634	0.383	G7	0.349	35.466	-2.019	27.513	1.061
G8	0.048	34.240	-2.680	6.030	0.162	G8	0.431	27.951	-2.152	32.305	1.319
G9	0.117	29.191	-4.269	11.958	0.497	G9	0.335	35.474	-2.912	26.760	1.205
G10	0.037	37.493	-3.175	4.347	0.138	G10	0.312	26.818	-0.930	25.664	0.690
G11	0.047	33.421	-3.177	5.526	0.174	G11	0.484	30.539	-1.790	34.716	1.420
G12	0.083	41.408	-1.026	9.314	0.181	G12	0.425	30.747	-3.443	31.718	1.643
G13	0.046	43.211	-2.083	5.286	0.137	G13	0.330	36.604	-2.780	26.537	1.171
G14	0.053	42.294	-1.225	5.971	0.132	G14	0.347	34.134	-5.027	27.627	1.596
G15	0.029	39.743	-0.662	3.379	0.053	G15	0.333	41.756	-3.603	26.572	1.322
Mean	0.057	37.438	-2.636	6.583	0.193	Mean	0.368	33.682	-2.852	28.640	1.289
Max	0.117	43.211	-0.662	11.958	0.497	Max	0.484	45.194	-0.930	34.716	1.643

Code	Wet season				SAR	Code	Dry season				SAR
Min	0.029	29.191	-4.382	3.379	0.053	Min	0.312	26.818	-5.027	25.664	0.690

Comments: KR - Kelly Ratio, MR - magnesium ration, RSC - Residual sodium carbonate, %Na - Sodium percentage, SAR - Sodium Adsorption Ration, Max - maximum, Min – minimum.

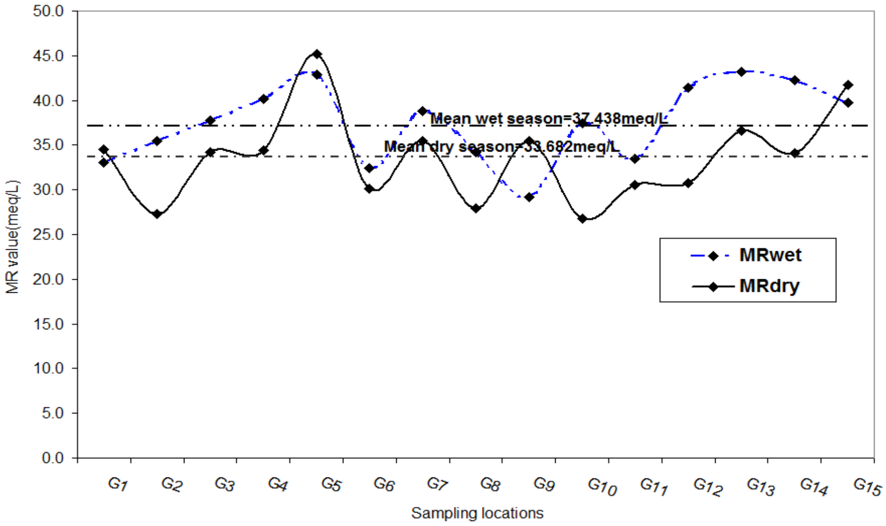

Fig. 5. Computed MR versus mean value

The %Na index shows that about 40% and 33.3% of the sampling locations had their mean values above the computed %Na index for dry and wet seasons respectively (Figure 6). It also inferred that all the samples are suitable for irrigation in both seasons, since the %Na index were found to be less than 60 meq/L.

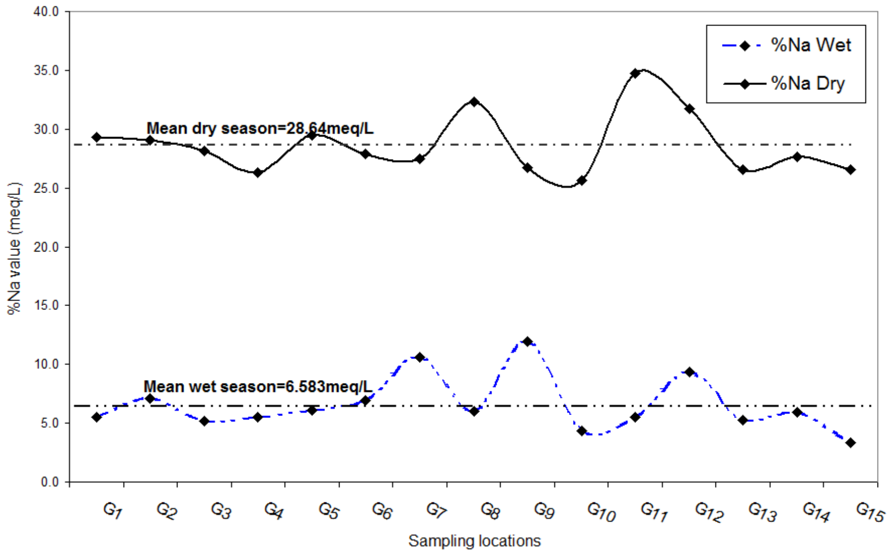

Fig. 6. Computed %Na versus mean value

Eaton (1950) proposed a classification scheme for the RSC. The RSC index indicates that the value between 1.25 and 2.50 meq/L is suitable, the value less than1.25 meq/L is marginally suitable while an RSC value above 2.50 meq/L is unsuitable for irrigation purpose. Accordingly, the results of the computed RSC index show that all the samples are suitable for irrigation in both seasons (Table 3). The sodium and salinity hazard were classified using the USSL (1954). The classification scheme classified sodium hazard (S) into four sub-zones as; low-sodium hazard (S1, <10), medium-sodium hazard (S2, 10 to 18), high-sodium hazard (S3, 18 to 26) and very-high sodium hazard (S4, >26), representing good, moderate, poor and very poor irrigation water quality respectively. Similarly, the salinity hazard (C) was divided into four sub-zones given as: low salinity hazard (C1, <250 µS/cm), medium-salinity hazard (C2, 250 to 750 µS/cm), high-salinity hazard (C3, 750 to 2,250 µS/cm) and very-high-salinity hazard (C4, >2,250 µS/cm) corresponding to good, moderate, poor and very poor water classes respectively.

According to these classification schemes, sodium hazard for both seasons shows that all the samples are characterised by low sodium hazard respectively (Figs.7 and 8). Unlike salinity hazard, it shows that all the samples are of a medium value in Amuwo, while the samples from Ojo indicate low, medium and high value(s) from location (s) G_{10}; G_{11}, $_{13}$ andG_{15}; and G_{12} and G $_{14}$ respectively in dry season (Fig. 7). High values of salinity hazard in these locations (G_{12} and G_{14}) in Ojo during the dry season could result from runoff from the farm and asphalt from the road into the shallow wells.

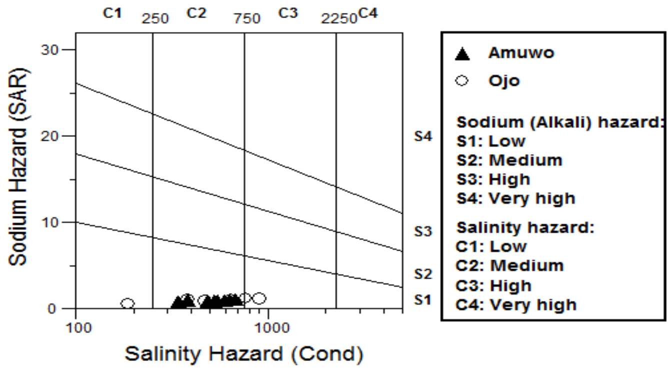

Fig. 7. Classification of salinity and sodium hazard in dry season

The extent of salinity hazard for wet season has revealed that locations G_{1-3} and G5; G_4, G_7 and $_{16,}$ and G_9 are characterised by low, medium and high value respectively in Amuwo, whereas samples from locations $G_{10, G\ 12\text{-}G15}$ and G_{11} indicate low and medium salinity hazard respectively in Ojo (Fig.8). The high salinity hazard from location G_9 in Amuwo during the wet season can be attributed to runoff from both anthropogenic, organic/inorganic manure into the well.

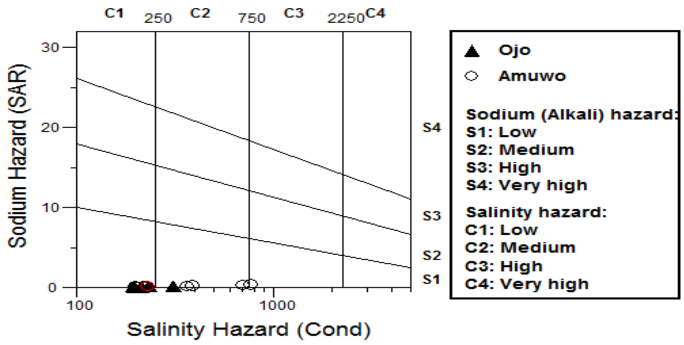

Fig. 8. Classification of salinity and sodium hazard in wet season

4. Conclusions

The study revealed that except for pH, the mean values of all the examined parameters i.e. EC, TDS, Ca, Mg, K, HCO_3, SO_4, CO_3 and Cl were higher in dry season compared to the wet season. The degree of relationship among the examined parameters shows that there are no significant correlations between the examined parameters in both seasons. The seasonal paired samples T-test shows that there are significant seasonal variations at P> 0.005 level of significance for four parameters Na, K, HCO_3 and SO_4. The results of the irrigation water quality assessment show that the well water samples are suitable according to Kelly ratio, magnesium ratio, residual sodium carbonate and percentage sodium indices in the study area in both seasons. The mean values of magnesium ratio from locations G_5 (both seasons) and G_{13} and G_{14} in wet season were observed to be relatively high in the study area. Spatially, the pattern of sodium and salinity hazard reveals that all the samples are suitable for irrigation except for locations G_{12} andG $_{14;}$ and G_9 from Ojo and Amuwo in dry and wet seasons respectively. The study concluded that the shallow well water quality of the study area is suitable for irrigation. Routine monitoring, appropriate treatment and investigation of soil quality test are recommended for further studies.

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Šachtinių šulinių vandens kokybės sezoniniai svyravimai Amuvo-Odofino ir Ojo savivaldybėse Lagose, Nigerijoje

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Penkiolikos seklių šulinių vanduo, naudojamas drėkinti, buvo analizuojamas 2012 m., drėgnaisiais ir sausaisiais sezonais, Amuvo-Odofino ir 2013 m. OJO savivaldybėse, Lagose, Nigerijoje. *In situ* parametrai – elektros laidumas, pH ir bendras ištirpusių kietųjų medžiagų kiekis – buvo nustatyti naudojant nešiojamus matavimo prietaisus. Bikarbonatas, kalcio karbonatas ir chloridas buvo nustatyti taikant titrimetrijos metodą. Magnis, kalis ir natris buvo nustatyti naudojant atominės absorbcijos spektrofotometrą, o sulfatas buvo nustatytas naudojant spektrofotometrą. Bendras kietumas buvo apskaičiuotas naudojant Fournierio lygtį. Tyrimo tikslas buvo išnagrinėti sezoninį negilių šulinių vandenį, skirtą laistyti. Buvo atlikta aprašomosios inferencialinės statistikos ir drėkinimo vandens kokybės rodiklių analizė. Rezultatai parodė, kad nustatytos vidutinės visų parametrų vertės buvo didesnės sausuoju sezonu nei drėgnuoju, išskyrus pH parametrą. Dvigubų mėginių T testas parodė aukštus sezoninius svyravimus $p < 0,05$ natriui, kaliui, bikarbonatui ir sulfatui. *Kelly* ir magnio santykis, natrio karbonato likučiai, natrio procentinė dalis ir natrio adsorbcijos koeficientas parodė, kad vandens kokybė yra tinkama drėkinti abiem sezonais. Erdvinis natrio ir druskingumo pavojaus modelis parodė, kad visi mėginiai yra tinkami laistyti, išskyrus vietose, kur buvo paimti G_{12}, G_{14} (sausuoju sezonu) ir G_9 (drėgnuoju sezonu) mėginiai. Buvo padaryta išvada, kad negilių šulinių vanduo tinkamas laistymo tikslais. Tolesniems tyrimams rekomenduojama atlikti reguliarią stebėseną, tinkamą valymą, taip pat dirvožemio kokybės tyrimus.