International Journal of Plant & Soil Science

Volume 35, Issue 19, Page 1354-1366, 2023; Article no.IJPSS.104324
ISSN: 2320-7035

Study of Salinity in Market Garden Production on the Togolese Coast

Afatsao Kossi Biava [a], Etse Kodjo Djidjolé [a*], Johnson Benziwa Nathalie [a], Sodjinou Komlan Edjedu [a], Aliaki Essozima [a], Radji Raoufou [a] and Quashie Marie-Luce Akossiwoa [a]

[a] Forest Research Laboratory, Physiology-Horticulture-Biotechnology Team (PHOBIOT), University of Lomé, 01BP 1515 Lomé 01, Togo.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i193679

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104324

Original Research Article

Received: 22/06/2023
Accepted: 25/08/2023
Published: 04/09/2023

ABSTRACT

Agriculture accounts for over 40% of Togo's GDP, and employs almost 65% of its working population. Market gardening, one of its sub-sectors, remains an important source of income and food self-sufficiency for rural and peri-urban populations. Among the peri-urban production zones, the coastline, by virtue of its geographical position, is sensitive to the salinisation of water and soil, as well as to sea spray. Salinity has a negative impact on market garden production. This study was therefore carried out to investigate the salinity of water and soil used in market garden production on the Togolese coast. To do this, measurements were taken of the electrical conductivity (EC) and pH of irrigation water and soil sampled in the Ablogamé and Agodéké districts, two production areas on the coastal strip. In each of these areas, water and soil samples were taken at three sites, with three samples per site, giving a total of six sites for analysis. At Ablogamé, the values for irrigation water ranged from 1113.67±3.06 µS/cm, 1971.67±9.24 µS/cm,

**Corresponding author: E-mail: kodjodetse@gmail.com;*

to 1926.33±6.51 µS/cm and for Agodéké, they ranged from 756.67 ± 1.53, 1016.00 ± 1.00 to 1178.33 ± 0.58 µS/cm. This shows that, according to CIRAD and WHO standards, the water analysed is classified as "salty", with a variability of EC within the same production zone, the exception being one of the Agodeke sites, which has soft water according to WHO standards. The FAO, for its part, classifies all the waters as having slight to moderate restrictions for irrigation. Furthermore, the EC values obtained are moderately and slightly high. In addition, those of the Agodéké sites, located at around 83 to 108 m from the sea, in the erosive zone, are generally lower than those of the Ablogamé sites located in the accumulation zone, at around 288 m to 406 m from the sea. The pH of the water is slightly alkaline. As for the soil, the EC values are below the norms at all the sites studied, thus demonstrating the non-saline nature of the market-garden production areas on the Togolese coastal strip. The soil pH is neutral to slightly alkaline. There is therefore a dynamism in the Togolese coastal aquifers that requires further studies to improve the performance of vegetable production on this coast.

Keywords: Salinity; market gardening; coastline; irrigation water; soil; production.

1. INTRODUCTION

Agriculture is one of the main sectors of activity contributing to the socio-economic development of populations. It employs more than 40% of the world's working population, including more than 52% in Africa and Asia [1]. Considered one of the most productive agricultural systems in Africa, market gardening plays an important role in human nutrition [2]. It employs a large proportion of urban dwellers [3-4]. In French-speaking Africa, fruit and vegetable production has increased by more than 50% in 10 years (between 2004 and 2014), according to statistics from the United Nations Food and Agriculture Organisation (FAO). This increase corresponds to no less than 43 million tonnes of fruit and vegetable production in West Africa. It should be noted that, since its introduction in colonial times, market gardening has taken off in particular with the development of cities and the growing demand for fresh market garden produce in West Africa [5]; and for African cities, this agriculture is part of their environment, because of the increasing demand for fresh vegetables in cities and the lack of employment, thus encouraging the development of this agriculture close to consumers [6,3,7].

In Togo, 40,000 tonnes of vegetables are produced every year [8]. The markets of Lomé and the country's other cities are supplied with fresh vegetables from market gardening. Many vegetables are grown on the coast [9]. However, agricultural development in coastal areas naturally implies a vulnerability of resources linked to the physiognomy of these areas and to processes inherent in the functioning of coastal areas. In coastal areas where farming is practised, the exploitation of underground resources is often confronted with the spread of the salt wedge, either naturally (variations in tides or tidal range, climate change, inverted estuary), or as a result of the heavy exploitation of underground resources [10]. All these combined actions expose the coastline to salinisation of the water and soil, and to sea spray. On the Togolese coast, crops are grown on sea sand and coastal aquifers are used for irrigation. The proximity of the plots to the ocean means that the production environment is exposed to marine influences, and salinity is one of the most important environmental constraints limiting plant productivity [11] and adversely affecting the growth of vegetable species at the seedling stage [12-14]. In addition, although a certain amount of work has been carried out on the Togolese coast, little has yet been done on market gardening in the face of salinity. Consequently, little scientific information is available on the quality of environmental elements in the market-garden production zone on the Togolese coast. The aim of this study is to analyze the salinity of irrigation water and soil used in market garden production on the Togolese coast.

2. MATERIALS AND METHODS

2.1 Study Area

The study covered two market-garden production zones on the Togolese coastal strip located in ecological zone V [15]. Administratively, they cover the districts of Ablogamé and Agodéké (Fig. 1), 16 km apart. The sites were selected because of their major role in supplying vegetables to the city of Lomé and their proximity to the ocean. These are areas that are subject to two opposing phenomena on the coast, namely fattening (Ablogamé) and erosion (Agodéké).

The two production zones enjoy a sub-equatorial Guinean climate with a bimodal regime, average annual rainfall of 860 mm/year and relative humidity of 80 to 90%. Average evapotranspiration is 1,540 mm/year and the average temperature ranges from 26 to 33°C (www. Clim.org and DGMN). The coastal zone is characterized by a low, sandy coastline marked by coastal erosion to the east of the main jetty of the port of Lomé, with a pronounced departure of sediments [16]. The soil is sandy [17].

2.2 Water and Soil Sampling

Irrigation water and sand were sampled in the two production zones in September, corresponding to the start of the short rainy season in 2020.

In each production zone, samples were taken at 3 sites per district: PK2, FK3 and FK11 for Ablogamé and AG1, AG25 and AG28 for Agodéké, with 3 water samples per sampling site, corresponding to 3 replicates (Fig. 2). The water samples were taken in clean 1.5-litre plastic bottles labeled with the date and code of the sampling point. They were kept in a cooler and then taken to the environmental geochemistry laboratory at the University of Lomé for analysis. At the time of sampling, the bottles were rinsed 3 times with the water to be sampled. The depths of the wells and boreholes were also recorded, as well as the distance of the sites from the ocean.

Soil samples were taken in the market garden plots at the same locations as the water samples. A composite sample weighing 2.5 kg was taken from 5 cores weighing 0.5 kg each at a depth of between 0 and 15 cm at the corners and centre of each sampling point, covering a 20 x 20 m² square. The composite samples obtained were each placed in a labeled plastic bag bearing the date and code of the sampling point, then transported to the same laboratory. The geographical coordinates of the various sampling sites were taken (Table 1).

2.3 Analyses Carried Out in the Laboratory

Measurements of electrical conductivity (EC) and pH were carried out on water and soil samples, in accordance with international standards NF T 9000 and NF EN 27888 respectively.

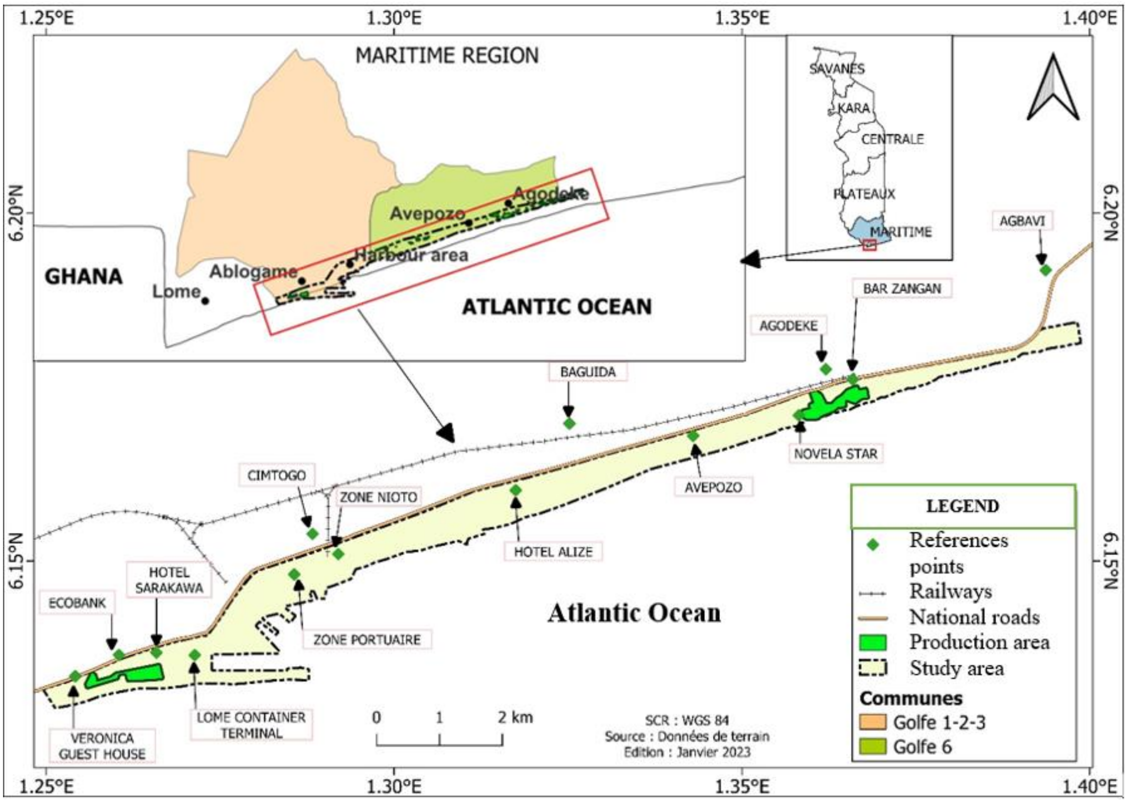

Fig. 1. Map showing the production areas studied

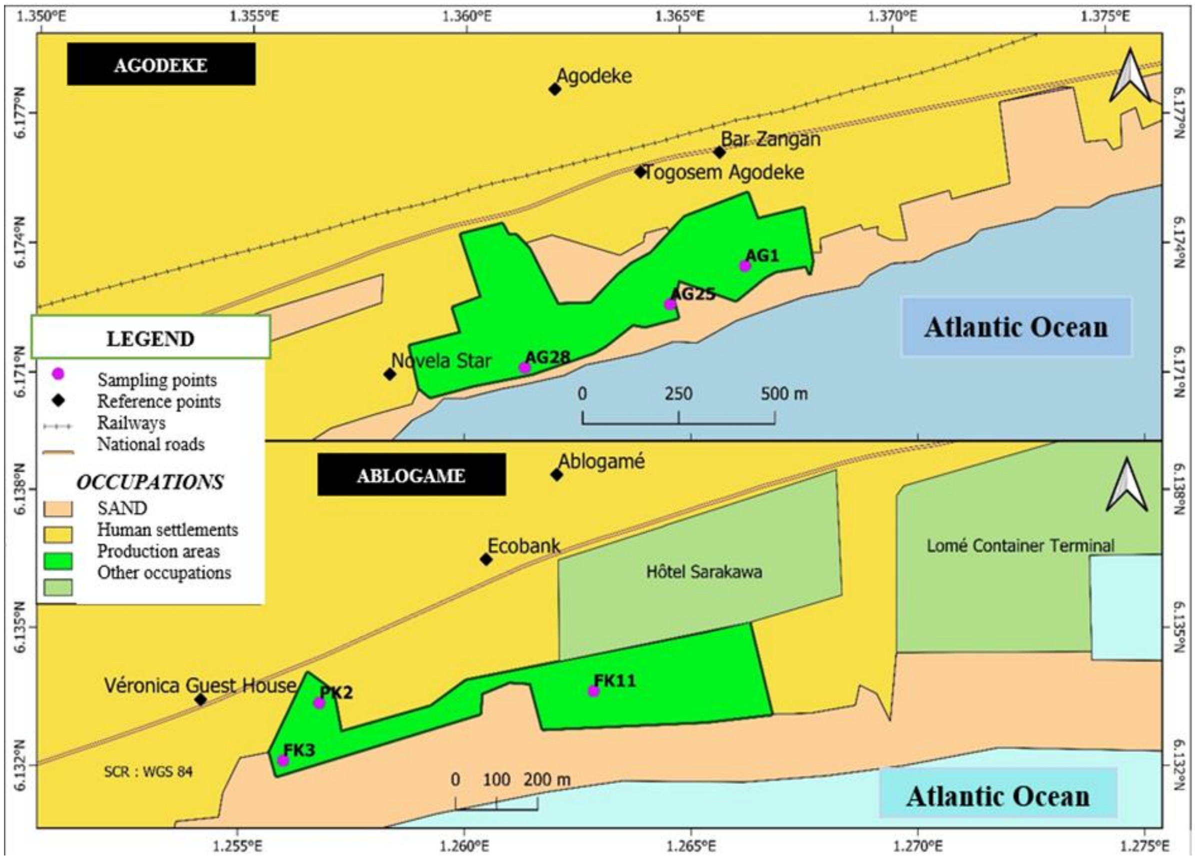

Fig. 2. Location of sampling sites in production areas

Table 1. GPS coordinates of water and soil sampling sites

Neighborhoods	Code	Well or borehole	GPS coordinates of sampling sites			Distance from the sea	Depth of wells or boreholes
			X(m)	Y(m)	Altitude (m)		
Ablogamé	1 PK2	Well	307081.66	678265.88	3 m	406 m	1.5 m
	2 FK3	borehole	307048.73	678126.64	1 m	288 m	6 m
	3 FK11	borehole	307391.39	678257.68	1 m	345 m	5 m
Agodeke	1 AG1	borehole	319258.46	682663.89	7 m	83 m	8 m
	2 AG25	borehole	319043.10	682615.40	7 m	128 m	12 m
	3 AG28	borehole	318728.98	682444.34	5 m	90.6 m	8 m

1PK1, 2FK3, 3FK11 = Sampling sites in the locality of Ablogamé; 1AG1, 2AG25, 3AG28 = Sampling sites in the locality of Agodeke.

A Saxin portable pH meter/conductimeter (reference SX736) calibrated with a range of specific standard solutions was used to determine EC and pH by immersing the electrodes in the samples taken.

Water analysis was carried out on the samples in a 1000 ml beaker. For each soil sample, the samples were dried in an oven at 40°C until the water in the sample was eliminated, then sieved through a sieve with a diameter of 2 mm. A soil solution was collected after filtering a mixture of 50 ml of demineralised water and 20 g of dried samples. The soil solutions were analyzed.

The pH and salinity indicators of the water and soil were measured (Table 2). EC and pH were used to assess the quality of the irrigation water and soil. All the parameters determined in the laboratory were interpreted in relation to the standards for interpreting irrigation water and soil analyses (Table 2).

Table 2. Definition standards for the indicators studied

pH			EC (µS/cm)			
Soil		Water	Soil		Irrigation water	
Threshold	**Appreciation**	**Maximum concentration**	**Threshold**	**Appreciation**	**Threshold**	**Appreciation**
< 4.5	Acid	5 to 7	<500	Not saline	< 250	Little salty
[4.5-6.5]	Slightly acid		[500-1000]	slightly saline	[250-750]	slightly salty
[6.5-7.5]	Neutral		[1000-2000]	Saline	[750-2250]	salty
[7.5-8.5]	Slightly alkaline		[2000-4000]	Very saline	> 2250	salty
> 8.5	Alkaline		> 4000	Extremely saline		
[18]		[19]	[20,21]		[22]	

2.4 Statistical Processing and Analysis

Excel 2016 was used to calculate the means and standard deviations and to construct the graphs. The Pearson correlation between pH and EC and an analysis of variance (ANOVA) were performed using Minitab version 13 statistical software to compare the variability of pH and EC values between sampling sites. For all the results obtained, a Tukey test of univariate comparisons at the 5% threshold was performed.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 EC and pH of water

The EC values measured at the Agodéké sites are generally lower than those measured at the Ablogamé sites (Fig. 3). The EC values in the Ablogamé production zone were 1113.67 ± 3.06, 1926.33 ± 6.51 and 1971.67 ± 9.24 µS/cm (Fig. 3).

These EC values obtained are higher than the reference value (EC > 750 µS/cm). In addition, the EC values for the three sites were significantly different (*P* = 0.00) from one site to another (Table 3). Of the 3 points, the irrigation water at site PK2 had a lower EC (1113.67 ± 3.06 µS/cm). The water therefore has a low EC value and is therefore poorly mineralised. However, the water at sites FK3 and FK11, with EC values of 1971.67 ± 9.24 µS/cm and 1926.33 ± 6.51 µS/cm respectively, could be described as moderately mineralised.

For the Agodéké production zone, the EC values are 1178.33 ± 0.58 µS/cm for AG25, 1016.00 ± 1.00 for AG28 and 756.67 ± 1.53 µS/cm for AG1 (Table 4). The waters at sites AG25 and AG28 have EC values between 750 µS/cm and 2250 µS/cm, with low values. The lowest EC value was obtained at site AG1 (756.67 ± 1.53 µS/cm), which is slightly higher than the reference value (EC=750 µS/cm) (Table 2). Salinity in the Agodéké production zone could be described as low to slight.

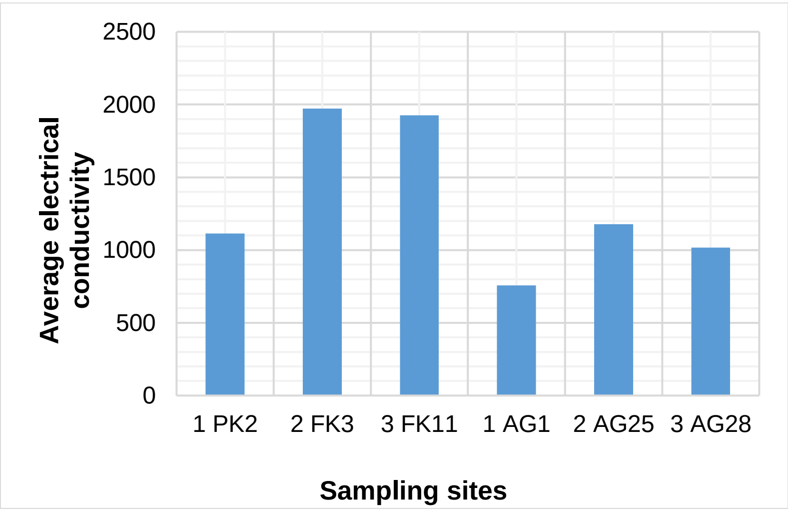

Fig. 3. Means values of electrical conductivity (µS/cm) of the various sampling sites

Table 3. Measurement of Electrical Conductivity (EC, µS/cm) and pH of irrigation water

Neighborhoods	Wells or boreholes	Distance from the sea	Depth of wells or boreholes	EC (µS/cm)	pH	Irrigation water [22] Reference value	
						EC threshold (µS/cm	Appreciation
Ablogamé	1 PK2	406 m	1.5 m	1113.67 ± 3.06 **c**	7.77 ± 0.05 a	< 250	Little salty
	2 FK3	288 m	6 m	1971.67 ± 9.24 a	7.50 ± 0.02 b		
	3 FK11	345 m	5 m	1926.33 ± 6.51 b	7.71 ± 0.13 a	[250-750]	Slightly salt
	P			0.00	0.015		
Agodeke	1 AG1	83 m	8 m	756.67 ± 1.53 c	9.14 ± 0.15 a	]750-2250]	Salty
	2 AG25	128 m	12 m	1178.33 ± 0.58 a	7.56 ± 0.42 b		
	3 AG28	90.6 m	8 m	1016.00 ± 1.00 b	7.63 ± 0.05 b	> 2250	Very salty
	P			0.00	0.00		

Tukey's test: the means followed by different letters in the same column are significantly different at the threshold of 0.05.
1PK1, 2FK3, 3FK11 = Sampling sites in the locality of Ablogamé; 1AG1, 2AG25, 3AG28 = Sampling sites in the locality of Agodeke

Table 4. Measurement of electrical conductivity (EC, µS/cm) and soil pH

Neighborhoods	Sites	EC (µS/cm)			pH		
		Soil	Threshold	Appreciation	Soil	Threshold	Appreciation
Ablogame	1 PK2	124.00 ± 2.17 a	<500	Not saline	7.91 ± 0.25 a	< 4,5	Acid
	2 FK3	184.10 ± 9.63 b		slightly saline	8.05 ± 0.03 a	4,5-6,5	Slightly acid
	3 FK11	247.00 ± 23.43 c	500-1000	Saline	7.91 ± 0.025 a	6,5-7,5	Neutral
	P	0,00	1000-2000	Very saline	0,46	7,5-8,5	Slightly alkaline
Agodeke	1 AG1	129.37 ± 8.75 a	2000-4000	Extremely saline	7.44 ± 0.06 a	> 8,5	Alkaline
	2 AG25	144.80 ± 4.28 ab	> 4000	Not saline	7.51 ± 0.08 a		
	3AG28	187.67 ± 37.50 b	[21]		7.56 ± 0.05 a	[18]. adapted	
	P	0,04			0.16		

Tukey's test: the means followed by different letters in the same column are significantly different at the threshold of 0.05.
1PK1, 2FK3, 3FK11 = Sampling sites in the locality of Ablogamé; 1AG1, 2AG25, 3AG28 = Sampling sites in the locality of Agodeke.

About pH, the analyses reveal that the irrigation water in the Ablogamé and Agodéké production zones has an alkaline pH (pH > 7). At the Ablogamé site, the pH of the water was significantly different (P = 0.015). However, the pH of the water at sites PK2 (pH = 7.77 ± 0.047) and FK11 (pH = 7.71 ± 0.13) are equivalent. The highest pH value was obtained at site FK3 (pH = 7.50 ± 0.02) (Table 3). The water at the Ablogamé production sites is slightly above pH 7 and therefore slightly alkaline.

The highest pH value was obtained at the low EC site (Fig. 5). There was a weak negative correlation between pH and EC of the water at the various sites in the study area (R2 = 0.311; r = 0.558; p-value = 0.016). Statistical analysis of the parameters studied shows that EC and pH vary significantly according to site (P= $2e^{16}$).

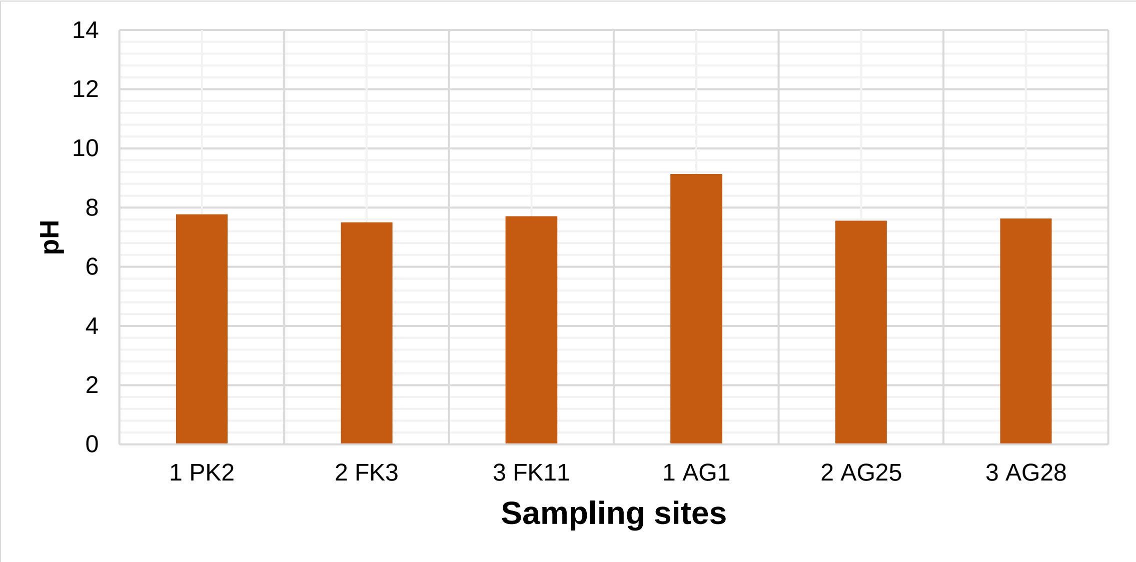

Fig. 4. pH values of irrigation water according to sampling sites

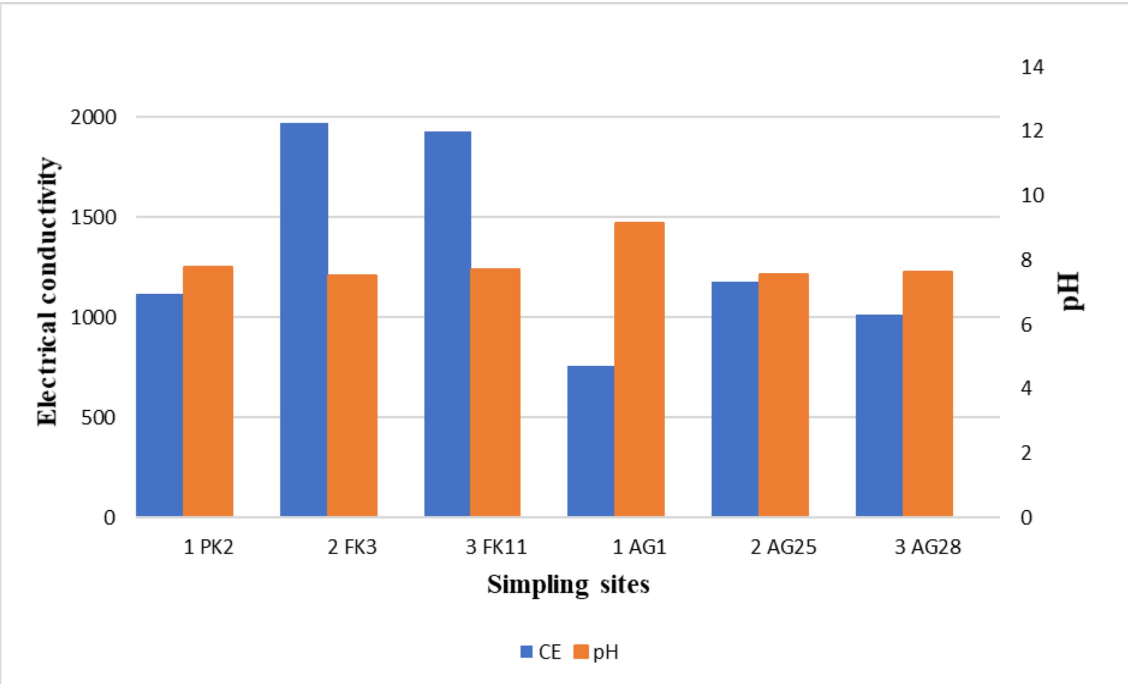

Fig. 5. Values of electrical conductivity (µS/cm) and pH according to sampling sites

3.1.2 EC and soil pH

Measured EC values are 124.00 ± 2.17 for PK2, 184.10 ± 9.63 for FK3 and 247.00 ± 23.43 for FK11 in the Ablogamé production zone. They were 129.37 ± 8.75, 144.80 ± 4.28 and 187.67 ± 37.50 respectively for the AG1, AG25 and AG28 sites in the Agodeke production zone (Fig. 6). The analyses reveal that the soil in the 0 - 15 cm horizons at all locations is not salty (EC < 500 µS/cm). For the Ablogamé district, the EC for the three sites differed significantly (*P* = 0.000) from one site to another (Table 4). The highest electrical conductivity was obtained at FK11, followed by FK3, and the lowest at PK2 (Fig. 6).

For Agodéké, the EC of the soil at site AG28 is higher than that of the soil at site AG1, with a low significance (*P* = 0.044), while that of the soil at site AG25 is equivalent to the EC of the soil at sites AG1 and AG28 (Table 4). The lowest soil EC was obtained at site AG1 (Fig. 6).

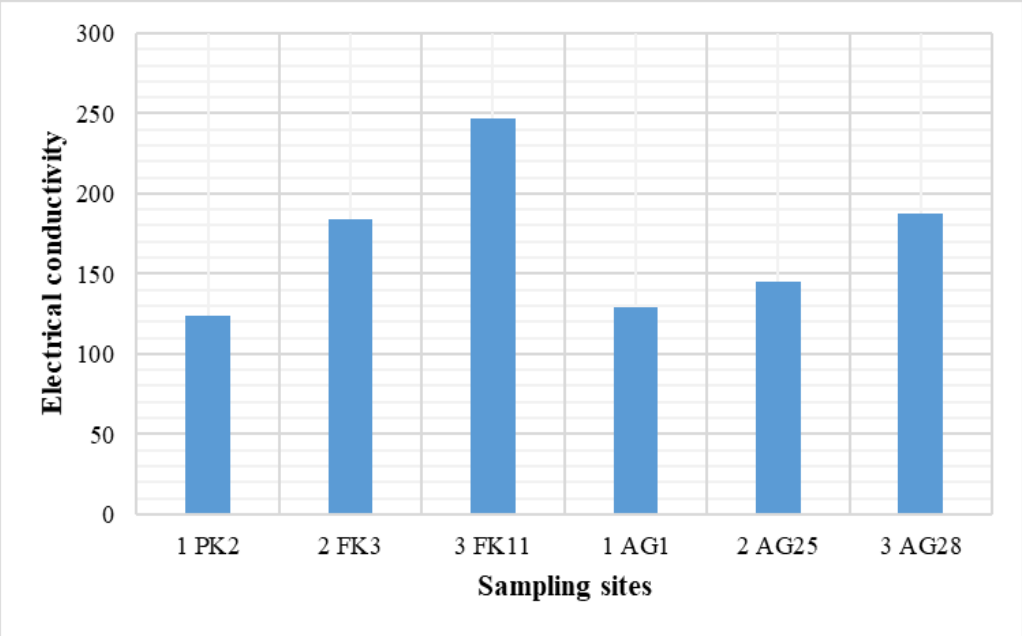

Fig. 6. Soil conductivity (µS/cm) at sampling sites

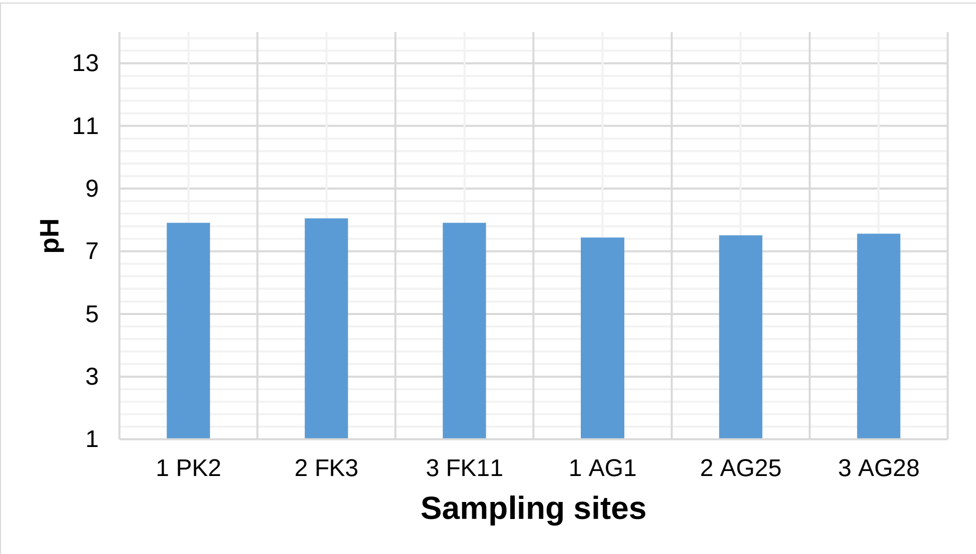

Fig. 7. pH values of sampling sites

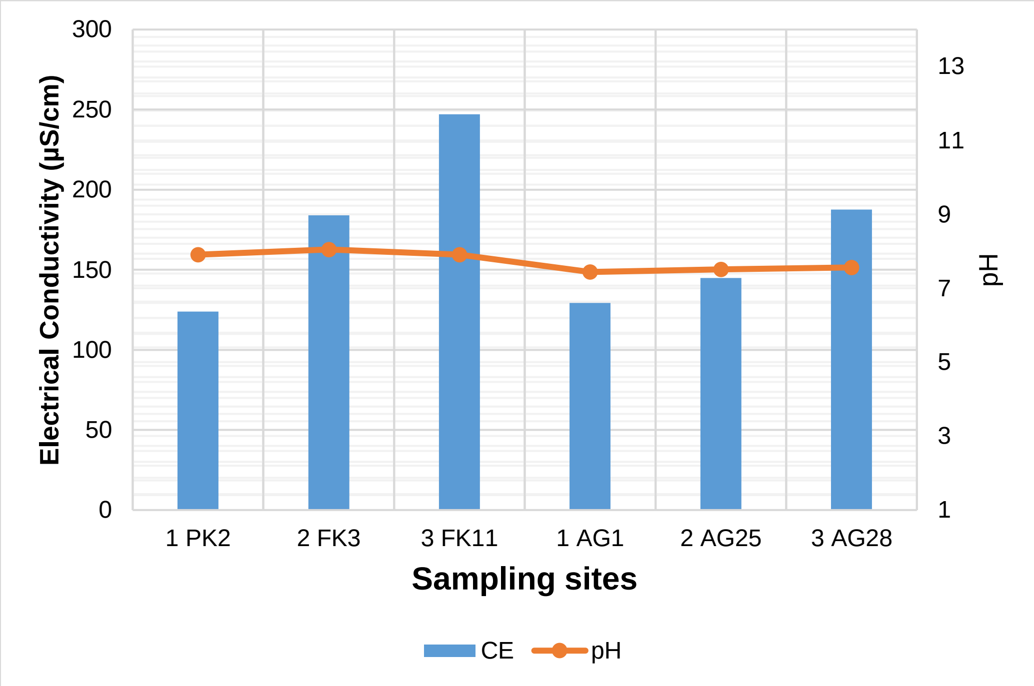

Fig. 8. Electrical conductivity (µS/cm) and soil pH as a function of sampling site

The soil pH is 7.91 ± 0.02 for site FK11, 7.91 ± 0.25 for site PK2 and 8.05 ± 0.03 for site FK3 in the Ablogamé production zone in the surface horizons (0 - 15 cm). It is 7.44 ± 0.06, 7.5133 ± 0.08 and 7.56 ± 0.05 in the 0 - 15 cm surface horizons at sites AG1, AG25 and AG28 in the Agodéké production zone (Fig. 6).

The soil is neutral to slightly alkaline at Ablogamé and slightly alkaline to alkaline at Agodéke. On the Ablogamé site, the pH of the 0 - 15 cm soils did not differ significantly ($p = 0.463$) from one another; the same was true for the Agodéké sites ($p = 0.158$) (Table 4).

In each production zone, the soil pHs of the sites are equivalent despite the differences between the ECs (Table 4; Fig. 8).

3.2 Discussion

According to CIRAD standards [22] and WHO standards [23], the waters analysed are classified as "salty" with a variability of EC within the same production area, with the exception of one site in Agodeke which has soft water in accordance with WHO standards. Furthermore, if we consider the EC values obtained for the so-called saline waters, these can be considered as slightly and moderately saline waters compared with the conductivity limit values defined in the CIRAD standards [22]. Still in the classification of irrigation waters, according to Maynard and Hochmuth [24], the EC obtained are categorised in the class of waters with light problem severity. The FAO, for its part, according to its guidelines for assessing water quality based on the work of Ayers and Westcot [25], classifies the waters studied in the range of light to moderate restrictions, as their EC values are between 700 and 3000 µS/cm with a pH between 6.5 and 8.4 with the exception of site AG1, which has a pH greater than 8.4 in the Agodéké zone. According to Traoré et al. [26], waters of marine origin are basic and those of continental origin are acidic. Thus, the basicity of the water would be linked to the marine influence in the production zones studied. Paradoxically, this observation is not consistent with the EC values obtained, as the highest pH is obtained at the site with the lowest EC. In addition, the EC values for all the waters analysed are slightly and moderately high. Thus, the increase in pH observed at site AG1 in the Agodéké production zone could be due to a local anthropic action or to a local geological or pedological formation. Groundwater conductivity varies according to the geological nature of the aquifer, its thickness and the residence time of the water in the aquifer [27]. Similarly, dissolved salt levels are the result of the contribution of major water constituents such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-} and HCO_3^{-} ions [28-29].

According to the WHO classification [23], there is a formation of freshwater on the Togolese coast, particularly at one of the Agodéké sites. The levels of major elements in coastal hydrosystems generally depend on exchanges between the ocean and continental water inputs [30-33]. In these exchanges, salt water can penetrate the continent depending on the natural conditions and the conditions of exploitation. Because it is denser than freshwater, saltwater forms a salty wedge beneath freshwater. Furthermore, the groundwater in coastal aquifers is hydraulically continuous with the sea. Under these conditions, if the hydraulic head, which is reflected in the level of the water table in the underground reservoir, is higher than sea level, and the physical properties allow for flow, then the groundwater will flow towards the sea. Freshwater outflows can thus take place either diffusely through the sediments, or in a more localised manner in the form of submarine springs [34].

The variability of EC observed in the same production areas could be explained by the diversity of anthropogenic actions on the groundwater resource. Anthropogenic pollution associated with the erosion of geological formations modifies the content of chemical elements in groundwater [35]. Similarly, the exploitation of freshwater reservoirs creates a vacuum that is filled by seawater. As a result, anthropogenic pressure is a source of water salinisation [27].

With regard to distance from the ocean, the Togolese coastline is subject to an accumulation phenomenon due exclusively to the presence of a major obstacle upstream, such as the port jetty. Everywhere else, the coastline is subject to an erosive process that can be impressive, with average retreats that can exceed 10 metres per year [36]. As a result of this coastal dynamism, we expect a marine influence on coastal aquifers in erosive zones compared with accumulation zones. Curiously, the analyses show that the EC values measured at Agodeké, which is located in an erosive zone, are lower overall than those at Ablogamé, which is located in a sediment accumulation zone. Furthermore, according to previous studies carried out on the coastline, the borehole water in the Attiégou and Adamavo districts and that of the present study carried out on the coastal strip, located in order at 3500 m, 3000 m and 406 m from the sea, shows EC values varying respectively from 3422 to 6554 µS/cm; 1129 to 2750 µS/cm and 756.67 to 1971.67 µS/cm. It can be seen that the EC values follow a decreasing gradient the closer you get to the sea. This observation is contrary to that of Ahmed [37]. Indeed, he observed on the Moroccan Atlantic coast in the Oualidia sahel, conductivities that vary from 6 mS/cm on average to 0.8 mS/cm on average, moving inland where conductivities become lower and lower. According to the results, the hydrogeochemical analysis showed that the most mineralised zone is closest to the ocean, within the first kilometre, concluding a marine intrusion on the Moroccan coast in the Oualidia sahel. The low EC values found on the Togolese coast, compared with those obtained by Ahmed, are therefore not linked to marine intrusion.

The EC values observed on the coast would therefore not be linked to the marine influence. Orou et al, [27] explain this phenomenon by the differences in geological and hydrogeological formations in addition to anthropogenic activities that can influence the EC of groundwater. Several authors, such as Marsily et al. [38] and Ahoussi et al. [39], attest that the decomposition of plant matter, with the production of certain molecules in the first layers of the soil, also influences groundwater. Diallo [40] maintains that it is the phenomenon of leaching, which carries all the dissolved elements to the depths of the soil, that influences groundwater quality.

According to the Durand [21] and Bocoum [41] scale (EC<500 µS/cm), the market garden soils at the Ablogamé and Agodéké sites are not saline. The pH also varies from neutral, slightly alkaline to alkaline [18]. The alkaline pH of the soil could be due to the presence of calcium on the coast. In fact, there is a clear correlation between pH and the exchangeable calcium content of soils [42]. Variations in exchangeable calcium concentrations can be linked to pH. When the pH is above 7, calcium accounts for at least two-thirds of exchangeable calcium [43]. According to Ndiaye et al. [44], soil alkalinity is generally due to the abundance of sodium and calcium ions, which are more important in coastal environments. In this case, alkalinisation can occur in an area that has been developed and irrigated by man within a few decades, considerably affecting the physical and hydric properties of the soil.

An analysis of the EC values of the water and soil in the study area shows that the EC values of the water are higher than those of the soil. The soil on the Togolese coast is sandy [17]. The importance of the sandy fraction would explain the poor soil structure, which favours the leaching of all the elements to depth [39]. The low EC of the soil compared with that of the groundwater could be explained by the leaching phenomenon at the production sites studied.

4. CONCLUSION

This study, devoted to an analysis of the market garden production environment on the Togolese coast, has shown firstly that the water used for irrigation and the soil used on the coast are suitable for market garden production. Secondly, the coastal aquifers that supply farmers' wells and boreholes are not subject to marine intrusion. However, the heterogeneity of the quality of the water used for irrigation means that additional knowledge is needed about the physical and chemical parameters of this water, and growers need to be made aware of the controlled use of pesticides and chemical fertilisers in order to preserve the current quality of the water used for irrigation and the soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Momagri. Chiffres-clés de l'Agriculture; 2016.
Available:http:// www.momagri.org/FR/chiffres-cles-de-l-agriculture/Avec-pres-de-40%25-de-la-population-activemondiale-l-agriculture-est-le-premier-pourvoyeur-demplois-de-la-planete_1066.html, (20/09/2017)
2. FAO,. Growing greener cities in Africa. First status report on urban and peri-urban horticulture in Africa. Roma: FAO; 2012
3. Maurice Dasylva, Ngor Ndour, Bienvenu Sambou, Richard Demba Diop, Multifunctionality of intra- and peri-urban agriculture in the commune of Ziguinchor in Senegal. American Journal of Innovative Research and Applied Sciences; 2020. ISSN 2429-5396 I
Available:www.american-jiras.com.
4. Dongmo T, Gockowski J, Hernandez S, Awono Ldk, Mbang A Moudon R. Peri-urban agriculture in Yaoundé: Its relationship to poverty reduction, economic development, biodiversity and environmental conservation. Tropicultura.2005;23(3):130-135.
5. Kone D, Cisse G, Seignez C, Holliger C. Macrophyte lagooning and irrigation in market gardening: study of an experimental station in Ouagadougou. Info CREPA. 2000;31:4-10.
6. Matimbya IK, Mahamba JA, Kapiri MM, Mulondi GK, Djurua IU, Valimunzigha CK, Mutiviti GP. Multifunctionality of urban and peri-urban agriculture: perceptions of supply and regulation in Butembo. Courses and Initiatives: Graben Interdisciplinary Review (PIRIG). 2023;(22):65-90.
Available:https://doi.org/10.57988/crig-2332
7. Dugue P, Soulard CT, Marraccini E, Houdart M, Michel I, Rhaidour M. Urban and peri-urban market gardening systems in the Mediterranean: A comparison between Meknes (Morocco), Montpellier (France) and Pisa (Italy). University of Sousse. Cirad-Agritrop; 2016
Available:https://agritrop.cirad.fr/584409/
8. INSEED; 2017.
Available:https://www.togofirst.com/en/agriculture/1503-2764-togo-exported-30-265-tons-of-fruits-and-vegetables-in-2017
9. Madjouma Kanda, Semihinva Akpavi, Kperkouma Wala, Gbandi Djaneye Boundjou Et Koffi Akpagana. Diversity of cultivated species and constraints on production in market gardening in Togo Int. J. Biol. Chem. Sci. 2014;8(1):115-127
10. Niang S, Abou SY, Ahmed Tidiane Faye A, Alassane Sow C, S Aldiouma SY Bas. Analysis by hydrogeochemical approach of the spatial distribution of salinite in the water table and quaternary sands of the niayes sector of gandiolais (Northern Senegalese Coast). European Scientific Journal, ESJ. 2020;16(24):104.
11. Husain T; Hussain A; Ahmed M. Studies of vegetative behavior and climatic effects on some pasture grasses growing wild in Pakistan. Pakistan J.Bot. 2009;41(5):2379-2386
12. Gildas Yenoukounme Sounou e, Baudouin Geoffroy Gouveitcha m, Atou r, Loko b, Koffi Kpinkoun j, Bernard Gandonou C. Effect of NaCl salt stress on growth, ions and organic solutes contents in a local cultivar kpinman of african eggplant (*Solanum macrocarpon* L) in the Republic of Benin. International Journal of Plant & Soil Science.2023;35(1):91–102.

13. Kpinkoun Jk, Zanklan SA, Komlan FA, Montcho D, Mensah Kinsou EET Gandonou CB. Evaluation of salinity resistance at the seedling stage of some pepper cultivars (Capsicum spp) from Benin. Journal of Applied Biosciences. 2019;133:13561-13573.
14. Gandonou CB, Houmba NR, Ahoton LE, Desquilbet S, Fakambi K, Datinon B, Marshall E.Evaluation of emergence and growth in twelve accessions of jatropha (Jatropha curcas) in Benin. Benin Agricultural Research Bulletin (BRAB). 2012;*72*:1840-7099.
15. Ern H. - Die Vegetation Togos : Gliederung, Gefahrdung, Erhaltung. Willdenowia. 1979;9:235-312
16. Koku-Azonko Fiagan. The impact of coastal erosion on artisanal maritime fishing in Togo. Journal of Tropical Geography and Environment*, n° 2*; 2013
17. Amey KB, Bedja K, Neglo K. Study of the transverse evolution of the differential and cumulative distributions and of the granular class of the marine aggregates of the Togolese coast. J. Rech. Science. Univ. Lomé (Togo), series n°2. 2005;7:13-20.
18. Chang HCY, Solomon NM, Wassarman DA, Karim FD, Therrien M., Rubin GM, Wolff T.the functions of phyllopodia in determining the fate of a subset of photoreceptors in Drosophila. Cell 1995;80(3):463--472.
19. Peterson HG. Water quality and Micro-irrigation for horticulture. Agriculture et Agroalimentaire Canada; 1999. Available: http://www.agr.gc.ca/pfra/water/microirr_e
20. Craaq. Guide de référence en fertilisation. Centre de référence en agriculture et agroalimentaire du Québec, Sainte-Foy. 2003;20:294.
21. Durand JH, Les sols irrigables, Agence de coopération culturelle et technique. P.U. France. 1983;190.
22. CIRAD - FRA, GRET - FRA, Ministère des affaires étrangères (France) - FRA. Mémento de l'agronome. Montpellier : CIRAD-GRET. 2002;1691.
23. World Health Organization, 2008. *'*Guidelines for drinkingwater quality'. 3ed incorporating 1st and 2nd addenda, Vol. 1, Recommendations, World Health Organization.
24. Maynard ND, Hochmuth JG. Knott's Handbook for Vegetable Growers. 1997;582 .
25. Westcot DW.. Reuse and disposal of higher salinity subsurface drainage water— A review.Agricultural water management.1988;14(1-4),483-511.
26. Traore Y, Ouattara K, Yeo D, Doumbia I, Coulibaly A. Research into the antifungal and antibacterial activities of the leaves of Annona senegalensis Pers. (Annonaceae). Journal of Applied biosciences. 2012; 58,4234-4242.
27. Orou KR, Coulibaly KJ, Tanoh AG, Ahoussi KE, Kissiedou KEP, Soro TD, Soro N. Quality and Vulnerability of water from the Altérites Aquifer in the Sub-Prefectures of Grand-Morié and Azaguié in the Department of Agboville in the South-East of Côte d'Ivoire. Ivorian Journal of Science and Technology.2016;28:243-272.
28. Riley JP, Chester R. Introduction to marine chemistry. Academic Press, London and New York. xiv + 465 p. &?6.00.$17.50; 1971.
29. Martin JM. Meybeck M. Elemental Mass-Balance of Material Carried by Major World Rivers. Marine Chemistry. 1979;7:173-206.
30. Millet. Hydrology and hydrochemistry of a tropical lagoon environment. Lake Togo Laboratory of Hydrology and Isotopic Geochemistry. Thesis; 1986.
31. Akouvi A, Dray M, Violette S, Marsily DE G, Zuppi GM.. The sedimentary coastal basin of Togo: example of a multilayered aquifer still influenced by a palaeo-seawater intrusion.Hydrogeology journal.2008;16:419-436.
32. Gnazou MDT., Etude hydrodynamique, hydrogéochimique, isotopique et modélisation de l’aquifère du paléocène du bassin sédimentaire côtier du Togo, Thèse de doctorat. Université de Lomé, *Togo*. 204p.+annexes; 2008.
33. Lebreton A, Tomecki R, Dziembowski A, Seraphin B. Endonucleolytic RNA cleavage by a eukaryotic exosome. Nature, 2008;456(7224):993-996.
34. Dörfliger Nathalie. Entre terre et mer, les eaux souterraines du littoral. Géosciences, 2013;17:74-81.
35. Ahonon AS, Gnandi K, Simtako B, Amouzou H. Assessment of the physicochemical and bacteriological quality of surface water in the areas; 2019.
36. Ozer Pierre, Hountondji Yvon-Carmen, De Longueville, Florence. Recent evolution of the coastline in the Gulf of Benin. Examples from Togo and Benin; In Geo-Eco-Trop: International Journal of Geology,

Geography and Tropical Ecology. 2017;41 (3).

37. Ahmed Fadili, Hydrogeological and geophysical study of the extension of marine intrusion in the Oualidia Sahel (Morocco): Statistical analysis, hydrochemistry and electrical prospecting. Environments and Global Changes. University of Chouaïb Doukkali Faculty of Sciences El Jadida. French. ffNNT : ff. fftel-01294119f; 2014.
38. Marsily G, Besbes M. Groundwater. In Annales des Mines-Responsibility and environment. 2017; 2;25-30. Cairn/Softwin. DOI:10.3917/re1.086.0025. URL:https://www.cairn.info/revue-responsabilite-et-environnement-2017-2-page-25.htm
39. Ahoussi KE, Soro N, Koffi YB, Soro G et. Biemi J. Origin of water mineralization in discontinuous aquifers under forest cover in the southern zone of Côte d'Ivoire: Case of the Abidjan-Agboville region. International Journal of Biological and Chemical Sciences. 2010;4(3):782-797.
40. Diallo MD, Guisse A, Sall SN, Dick RP, Assigbetse KB, Dieng AL. Chotte JL. Influence of tropical leaf litters on N mineralization and community structure of ammonia-oxidizing bacteria. Biotechnologie, Agronomie, Société et Environnement, 2015;19:145-155.
41. BocoumM.Méthodes d'analyses des sols. Doc de travail. Institut National de Pédologie, Dakar – Sénégal. 2004;55.
42. Ndiaye M, Metghari ELL, Soumah MM, Sow ML. Management of biomedical waste in five hospital structures in Dakar, Senegal; 2012.
43. Pernes-Debuyser A, Tessier D. Influence of pH on soil properties: the long-term test of 42 plots at Versailles Chemistry Journal of Water Science; 2002.
44. Ndiaye O, Diallo A, Matty F, Thiaw A, Fall RD, Guisse A. Characterization of soils in the Niayes area of Pikine and Saint Louis (Senegal). International Journal of Biological and Chemical Sciences. 2012; 6(1):519-528. DOI:10.4314/ijbcs.v6i1.46

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104324