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Advances in Ecological and Environmental Research (ISSN 2517-9454, USA), 257-274 | Science Signpost Publishing

Identification of Unfavorable Climate and Sanitary Periods in Oueme Department in Benin (West Africa)

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Received: October 05, 2018 / Accepted: October 28, 2018 / Published: November 25, 2018

Abstract: Since the advent of climate change, the effect of climate on the human body is increasingly felt, this leads to the recrudescence of several pathologies. This study aims to determine the adverse climatic and health periods for people who are sensitive to malaria and acute respiratory infections in the department of Ouémé in Benin. To do this, this study was conducted using descriptive statistics methods, and calculation of bioclimatic indices (K and THI). The data used are the climatological data (rainfall, temperature, relative humidity, insolation and wind) on a monthly scale over the period 1971-2015 and available epidemiological data of all the health centres of the department. The results obtained make it possible to define the months of June, July, August, September and October as unfavourable weather-health periods for malaria and the months of January, February, March, April, May, December and November, as an unfavourable climatic-sanitary period for people sensitive to IRA. In conclusion, the health and sanitary periods unfavourable for the IRA are the harmattan months (January, February, December) and the unfavourable weather-health periods for the malaria-sensitive are the beginning months (March and September) and the end (July and September). November) of rainy seasons. It can be noted that, from the point of view of health and climate, adaptation measures are necessary for the sustainable development of the country.

Keywords: Benin, Department of Ouémé, bioclimatic environments, climato-sanitary, malaria, acute respiratory infections (ARI)

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1. Introduction

The effects of climate on humans and their health are well established (Houssou, 1998, Médéou, 2015, Boko et al., 2014). In other words, it is recognized that the exposure of a living human organism to a cold or hot environment can cause more or less serious reactions of the human organism (Clédjo, 1993, Ganem et al., 2004). And the occurrence of a pathology is related to the period and the intensity of the exposure of the organism (Houssou et al., 2006).

In Benin and particularly in the department of Ouémé, bioclimatic environments are undergoing more and more changes (Boko et al., 2014). These changes are more difficult and constitute a factor of embarrassment for the population and especially for children from 0 to 5 years old who are very sensitive to malaria and ARI. The objective of this work is to highlight periods of high prevalence of pathologies of malaria and ARI in the department of Ouémé.

2. Geographical Framework of the Study

The study area is the department of Ouémé located in south-east Benin. It is bordered to the South by the Atlantic Ocean and the Littoral Department, to the North by the Plateau Department, to the West by the Atlantic Department and to the East by the Federal Republic of Nigeria (Figure 1). With 405 villages and an area of 1,281 km², the department of Ouémé is made up of nine (9) communes namely: Adjarra, Akpro-Missérété, Avrankou, Adjohoun, Bonou, Dangbo, Sèmè-Kpodji, Aguégués and Porto Novo.

The department of Ouémé by its geographical situation, has a climate of the subequatorial type. Thus, the average monthly rainfall, has a bimodal aspect with two rainy seasons, the largest of which extends from April to July. They are alternated by two dry seasons from December to March on the one hand and from mid-July to August on the other hand. The months of May, June and October rainier with monthly rainfall amounts around 155 or even 198 mm. According to Houssou (1998), rains can be a favourable factor for the prevalence of diseases, especially when they are high.

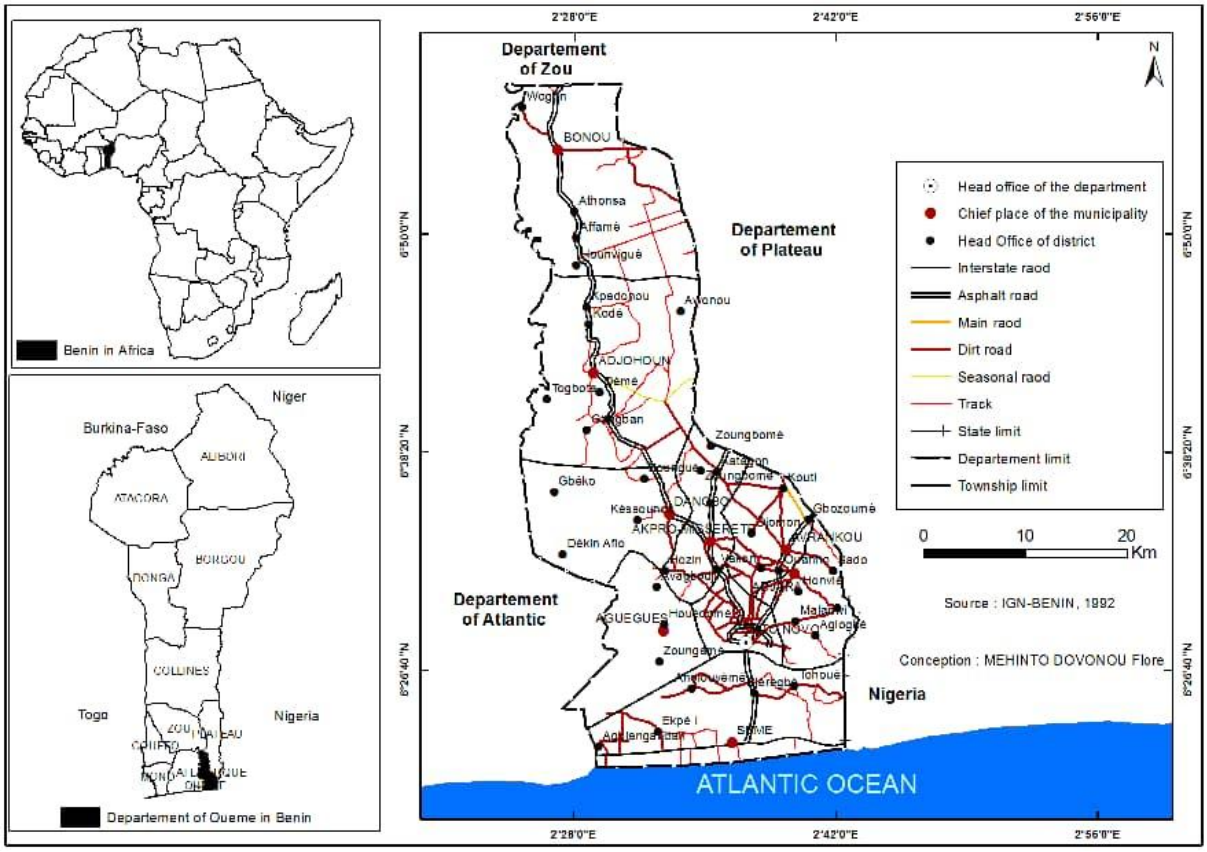

Figure 1 : Geographic location and administrative subdivision of the Department of Oueme

3. Methodology

3.1. Data used

These are climatological data and epidemiological data.

- **Climatological data**

The climatological data used are the temperature, the relative humidity, the wind speed, the height of the rain and the ETP, extracted from the base file of the Weather-Benin service in Cotonou. These data are in monthly and yearly time steps and cover a period of 30 years (1985 to 2014). The climatological series served as a basis for the determination of bioclimatic environments. Climate data series with a gap rate of 5% or less have been filled. The missing data are replaced by those of the neighboring station with the highest coefficient of determination (r) over the year considered (simple linear regression) (Doukpolo, 2006).

- **Epidemiological data**

These data concern the cases of malaria and acute respiratory infections recorded in the health centers of the Department of Ouémé. A total of 25 Health Centers (HC), 18 clinics, 10 District Health Centers (CSA), 1 Communal Health Center (CSC), 2 Zone Hospitals (HZ) and 12 Village Health Units (UVS) have been selected to have information on the periodicity of pathologies.

The following figure illustrates all the health centers whose data were considered.

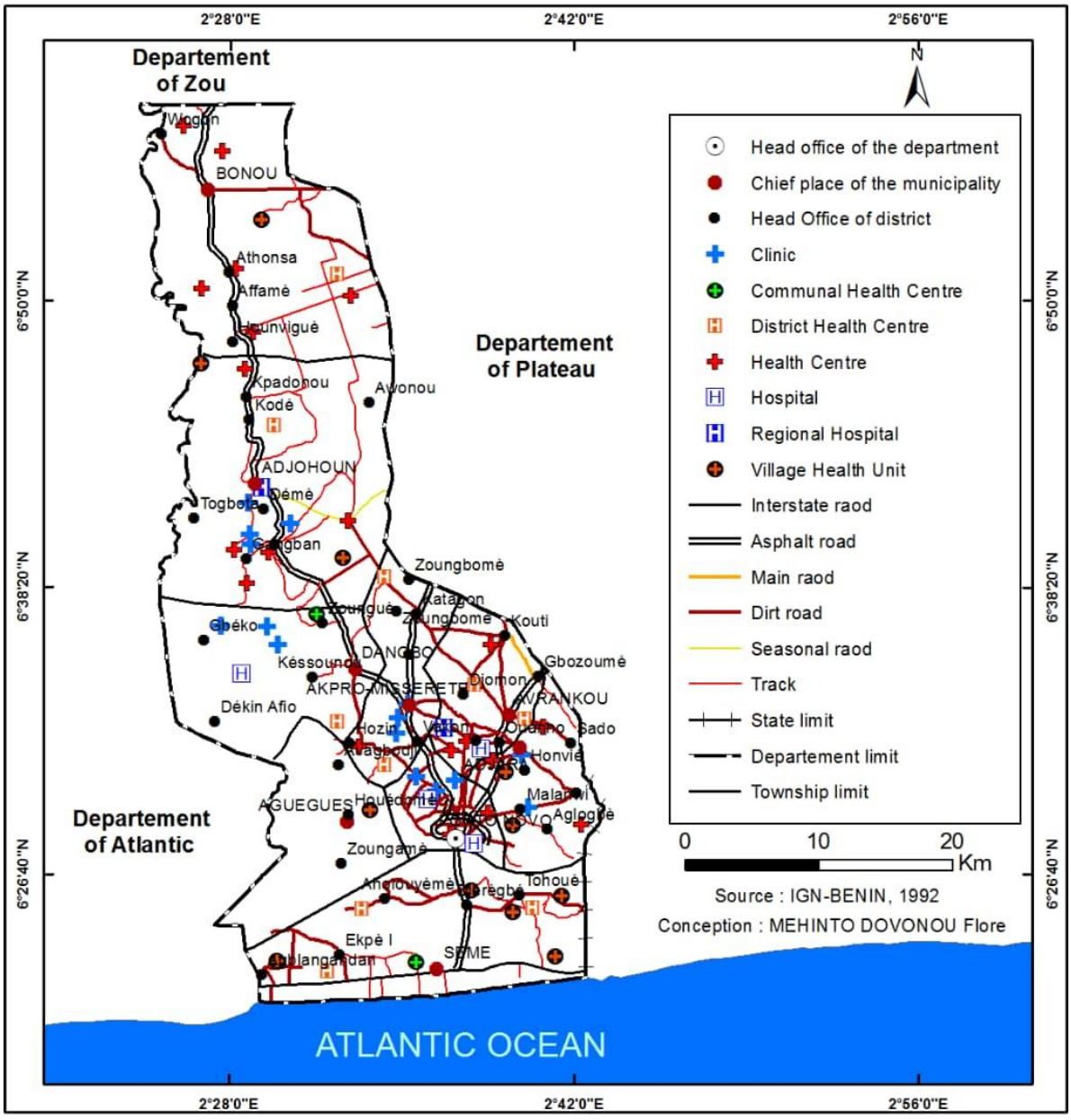

Figure 2: Distribution of selected health centres for epidemiological data collection

These data are provided by the statistics department of the University Hospital Center of Ouémé-Plateau (CHUOP) in Porto-Novo.

Legend :

CS : *Health Centre;* ***CSA :*** *District Health Centre ;*

CSC : *Communal Health Centre;* ***HZ :*** *Regional Hospital*

UVS : *Village Health Unit;*

3.2. Data processing methods

The information collected from the elaborated questionnaires is automatically analyzed. This made it possible to have a database for producing tables and graphs.

For the determination of unfavourable bioclimatic periods for malaria and ARI-susceptible individuals, a discriminant analysis in PCA (Principal Component Analysis) was performed. The first two axes (the first factorial plane) have been retained because it is more comprehensible to the eye and it explains more than 70% of the cloud (variables and individuals). Clouds of points with a strong correlation with axis 1 are considered favourable period, with axis 2, as unfavourable period.

The method for determining bioclimatic atmospheres was also carried out using two indices: the thermo-hygrometric index (THI) and the air cooling index (K).

The thermo-hygrometric index (THI) formula of Thoms (1959) is as follows:

$THI = [T- (0.55-0.0055U\%) (T-14.5)]$

with T (°C) = air temperature and U (%) = relative humidity.

Table I shows the scales of interpretation of the values resulting from the calculations of this index.

Table 1: Interpretation scales of THI

THI (°C) CONDITIONS	INTERPRETATIONS
$THI < 0$	very cold or cold atmosphere
$0 \leq THI \leq 15$	cool atmosphere
$15 \leq THI \leq 20$	relaxing, comfortable atmosphere (relaxing cooling)
$20 \leq THI \leq 26$	warm atmosphere more or less endurable
$26 \leq THI \leq 29$	very hot atmosphere uncomfortable
$THI>30$	torrid atmosphere

Source : Thoms, 1959

K is an index developed in the form of the index of air cooling capacity (Siple and Passel, 1945) and which states as follows:

$$K = (10.45 + 10\sqrt{v} - V)(33 - T)$$

With K the cooling capacity of the air, V the wind speed and T the ambient temperature.

Table II shows the scales of interpretation of the values resulting from the calculations of this index.

Table 2: K Interpretation Scales

K (Kcal/h/m2) CONDITIONS	INTERPRETATIONS
$K < 0$	torrid atmosphere
$0 \leq K \leq 150$	very hot atmosphere uncomfortable
$150 \leq K \leq 300$	warm atmosphere more or less endurable
$300 \leq K \leq 600$	comfortable atmosphere, (relaxing cooling)

Source : Siple and Passel, 1945

As for the calculation of bioclimatic index, it was realized thanks to the software BioKlima © v 2.6. The software can be downloaded from: www.igipz.pan.pl/klimat/blaz/bioklima.htm. These methods have yielded some results.

4. Results and Discussion

All the results' articulates around the climatic episodes, the types of time, the evolution of the bioclimatic atmospheres and finally the synthesis of the ambiances in connection with the pathologies in the department of Oueme.

4.1. Climatic episodes and type of bioclimatic weather in the department of Oueme

The analysis of climatological data, fieldwork and information from the bibliographic literature allowed for a synthesis of the main types of weather in the study area. Thus, several climatic episodes have been identified: the dry seasons (one large and one small) and the rainy seasons (one large and one small) alternate. Table 3 summarizes these episodes and type of associated bioclimatic time.

Table 3: Annual climatic episodes and dominant bioclimatic traits

Month	Climatic Episodes	Dominant bioclimatic traits
January	Harmattan	Cool and foggy weather in the morning and very hot in the afternoon. The sky is slightly cloudy with weak winds and an average daily sunshine duration of 7 hours. Rainfall is rare or almost absent. The nights are marked by feelings of freshness.
February	Torrid atmosphere	Hot and slightly humid weather with rainy-stormy activities. Rainfall heights are low with generally a reduction in visibility under dust mists, dry or wet and / or fog. The mornings are marked by a little cool while in the afternoon reigns a strong heat. The daily duration of insolation is long and about 7 hours. Very hot and sunny weather with a daily duration of insolation of 7 hours. Rainfall is rare and of low intensity. The days and the nights record high temperatures expressing sensations of great heat.
March		Very hot and sunny weather with weak rainy-stormy activities. Rainfall heights are low with generally cloudy skies. Days and nights are marked by high temperatures reflecting feelings of high heat.
April	Transition period between dry and wet season	Hot, sunny weather with moderate rain and thunderstorm activity. Days and nights are marked by a feeling of warmth. Temperatures are high and vary between 22 °C and 34 °C. Visibility is often reduced under wet drizzle or fog. The sky is slightly cloudy. Hot weather with rainy-stormy activities that can sometimes be intense. The rainfall is average with dews at sunrise. The sky is very cloudy with a short duration of sunstroke of about 4 hours.
May	Rainy season	Hot and rainy weather. The rains are frequent and abundant and occur mostly at night. Mornings and nights are sometimes characterized by feelings of freshness. The sky is very cloudy with a short duration of sunstroke of about 4 hours. Hot and rainy weather with a high daily amount of precipitation. The sky is

		often cloudy. The duration of the insolation is low and is on average of 3 hours and a half.
June		Hot and rainy weather. The rains are significant with a very cloudy sky. The daily duration of sunstroke is relatively long (on average 6 hours) and the nights are marked by a feeling of freshness.
July		Hot and rainy weather with significant rainfall. The sky is very cloudy but with a daily duration of sunstroke relatively long (average of 6 hours). The nights are marked by a feeling of freshness.
August		Hot weather with some stormy events sometimes accompanied by light rain. The duration of the insolation is high and exceeds on average 7 hours and a half. The diurnal and nocturnal thermal environment is hot.
September	Transition period between the rainy season and the dry season	Cool and misty in the morning and warm in the afternoon. The nights are marked by feelings of freshness. The sky is slightly cloudy with weak winds and an average daily sunshine duration of 7 hours.
October		Cool and foggy weather in the morning and very hot in the afternoon. The sky is slightly cloudy with weak winds and an average daily sunshine duration of 7 hours. Rainfall is rare or almost absent. The nights are marked by feelings of freshness.
November	Start of the big dry season	Hot and slightly humid weather with rainy-stormy activities. Rainfall heights are low with generally a reduction in visibility under dust mists, dry or wet and / or fog. The mornings are marked by a little cool while in the afternoon reigns a strong heat. The daily duration of insolation is long and about 7 hours.
December	Harmattan	Very hot and sunny weather with a daily duration of insolation of 7 hours. Rainfall is rare and of low intensity. The days and the nights record high temperatures expressing sensations of great heat.

Source: *Documentary synthesis and fieldwork (2016)*

The analysis of the data in Table I reveals two situations: (1) a climatic episode with the types of bioclimatic time of the dry season; (2) a climatic episode with the bioclimatic weather types of the rainy season.

Episodes and types of bioclimatic weather in the dry season.

The dry season includes three climatic episodes, namely the beginning of the long dry season (November), the Harmattan (December to February) and the period of hot heat (March-April). The beginning of the dry season is a climatic episode characterized by an increase in temperatures due to the decrease of rainy-storm activities.

The harmattan is a climatic episode imposed on the wind regime of sector E or N-E. It lasts two to three months. This mass of air is of continental origin, generated by the anticyclone (Amoussou, 2010). It is accompanied by a haze and a dry atmosphere because of the dominance of the continental air, translating a very great dryness of the air.

The minimum daily temperatures drop to 15 ℃ while the maximum temperatures vary globally between 33 and 40 °C during the day. This situation induces a cool thermal environment in the morning and hot in the early afternoon. The absence of rain associated with high insolation and low relative humidity (on average 60%) favor abundant sweating, especially during a forced activity (Boko 2014, Médéou 2015).

The gradual withdrawal of the harmattan in mid-February due to the change in the wind regime from the south, southwest or west, generates a torrid heat. This second climatic episode of the dry season covering mid-February to mid-April is very stressful for the human body. During this period, the air is hot as much during the day as at night when it is hot and stuffy.

The strong evaporation resulting from high temperatures and dry air causes soil denudation makes them conducive to release particles of different sizes that are mobilized by the wind, especially in harmattan time (Yaka et al., 2008). These lead to irritations of the nasopharyngeal mucosa favorable to respiratory diseases in general and epidemics of meningitis, measles, bronchitis, etc. (Yaka et al., 2008, Yaka, 2009, Médéou, 2015).

Climatic episodes and weather patterns of the rainy season.

The first climatic episode is experienced during the transition period between the dry and wet season (mid-April to mid-May). Under the impulse of oceanic high pressures centered on St. Helena Island, the meteorological equator arrives with large cloud masses and active nuclei of large cumulonimbus clouds (Afouda, 1990). The relative humidity of the air increases and approaches 75% in May. The maximum temperatures decrease and the temperature difference is reduced (23-33 ℃ in May). This slight decrease in temperature associated with the increased humidity of the air, the acceleration of the wind speed, the multiplication of rainy and stormy events mitigate the thermal environment. This period ends with the definitive installation of the rains.

The rainy season is characterized by high cloudiness, frequency and intensity of rainfall, which influence temperature and sunstroke (Boko, 1988). The daytime thermal differences are low. The minimum temperatures remain high while the maximum temperatures drop and do not exceed almost 28 ℃ in June-August. This thermometric decline is certainly influenced by cloudiness, but probably by the marine intrusion in coastal upwelling (Afouda, 1990).

The humidity of the air is high with an average of 80%. In addition, the winds are relatively strong and the turbulence effect maintains a hot and humid atmosphere (Boko, 2014). Especially in August, there is a decrease in rain events due to the thermoconvection which is not always in ideal conditions of realization. Only some exceptionally hot days will give rise to afternoon rains typical of convective rainfall (Afouda, 1990).

On the bioclimatic level, the populations feel sensations of freshness which progressively increase until the month of August. Between September and October there is another climatic episode during the transition period between the rainy season and the dry season. This type of weather is born with the weakening of the activity of the ITCZ, and subsequently of the weakening of the center of action of the high pressure of Île Sainte-Hélène (Afouda, 1990). The bioclimatic indicators of this type of weather is the return of storms and thermo-convective phenomena. The very active grain lines bring storm showers and the onset of a general rise in temperatures in the presence of a still humid atmosphere (70 to 80% relative humidity) (Médéou, 2015). They also favor afternoon rains in places. During this period, the atmosphere seems to be generally favorable to the activities even if the temperatures resume a gradual increase at the beginning of October.

4.2. Evolvement of bioclimatic environments in the department of Ouémé

The bioclimatic atmospheres were determined by means of the THI and K indices. The results obtained thanks to these calculations are therefore in two phases, namely: the atmospheres described by THI and the atmospheres described by K.

4.2.1. Atmospheres described by the cooling capacity of the air (K)

Figure 3 presents the ambiances described by the K index in the department of Ouémé.

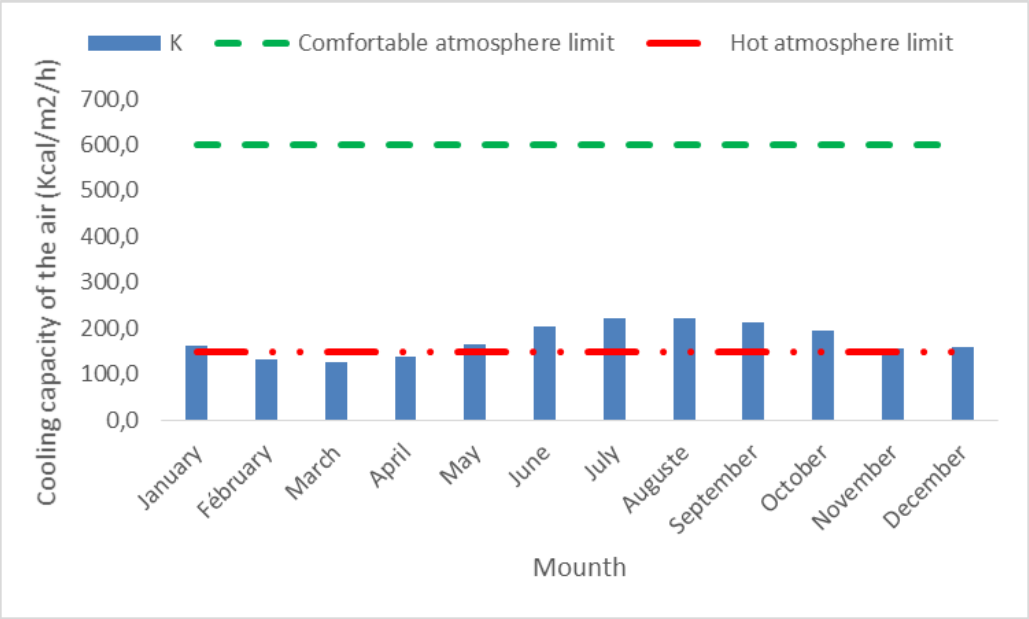

Figure 3: Inter-monthly change in the refrigerant power of the air from 1971 to 2015

Data Source: *ASECNA (2016)*

The analysis of this figure 3 shows that K values range between 125kcal / m ²/ h and 221 kcal / m ²/ h, from January to March, on the one hand, and around 80 kcal / m ²/ h in November to December on the other hand. From April to October, the air's cooling capacity sometimes reaches 154 kcal / m ²/ h (Houssou et al., 2010).

In January, the thermal environment is generally moderate and characterized by warm weather. The month of February is characterized by a moderate warm atmosphere (hypotonic) with a slight evolution towards a very hot (atonic) atmosphere. The months of March are found in a warm atmosphere overall moderate but warmer than the months of February

During the month of April, the weather is slightly warmer than in March and the k values oscillate around 140 kcal / m2 / h. The month of May is characterized by a slight comfort with 166 Kcal / m2 / h. The situation is almost identical during the months of June to October with K values above 149Kcal / m2 / h. These months are more or less relaxing, that is, hypotonic. During the months of November to January, the values of k are at the limit of the discomfort is 149 Kcal / m2 / h. These results are confirmed by those of Houssou et al. (2010) and Boko et al. (2014).

In the department of Ouémé, according to the values of K, the months that have globally acceptable

atmospheres are the months of May to October. The months of July and August seem to be the most comfortable (Boko, 2014). The children of this milieu live during the middle of the year in an uncomfortable atmosphere, which weakens their state of health.

4.2.2. Bioclimatic environments described by the THI

Figure 4 shows the atmospheres described by the THI index.

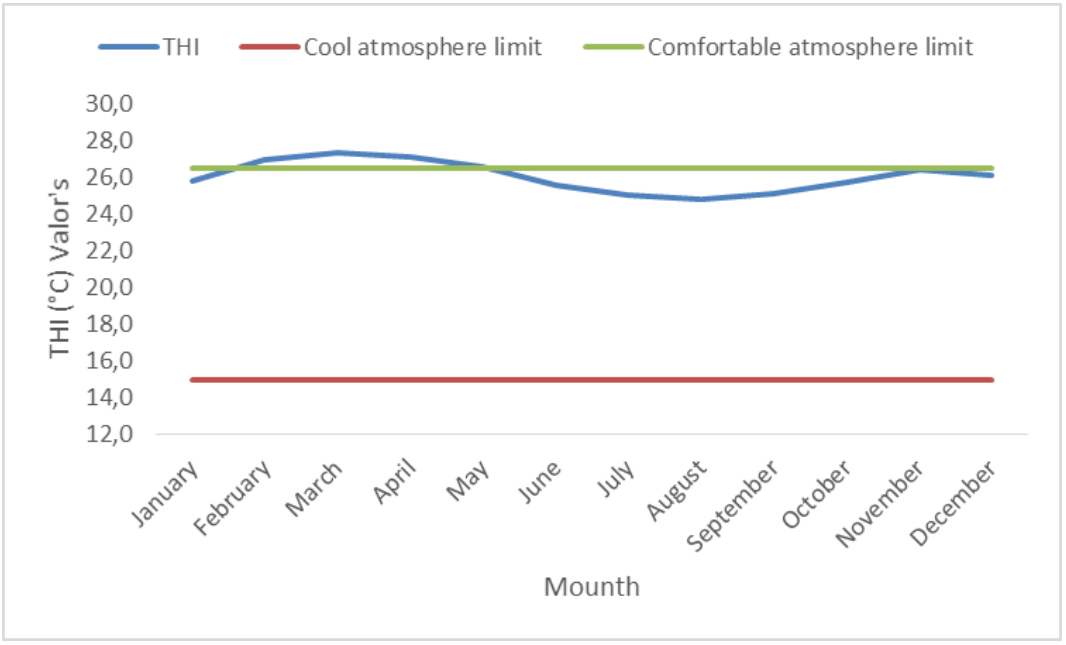

Figure 4: Inter-monthly evolution of the thermohygrometric index from 1971 to 2015

Data source: *ASECNA (2016)*

The analysis of fig. 4 shows that the thermo hygrometric index varies between the values 25 ℃. and 28 ℃. In January, the thermo hygrometric atmosphere is characterized by a generally favorable atmosphere (25 ℃). The months of February to May are characterized by a very hot atmosphere (Gbèdékoun, 2011, Ahoton, 2013).

During the months of June to October, the weather is more comfortable with THI values ranging from 25 to 26 ℃. The atmospheres of these months do not trigger the mechanisms of thermogenesis and thermolysis. Finally from November to December, the thermo-hygrometric atmosphere becomes slightly uncomfortable with THI values of 26.5 and 26.2 °C. These results are similar to those of Vitouley, (2015), Mehinto-Dovonou (2015).

In summary, only five (5) months out of twelve (12) experience a comfortable bioclimatic atmosphere for the populations and even more for the children from 0 to 5 years in the department of Ouémé.

4.3. Climatological and health periods in the department of Ouémé

Figure 5 present the synthesis of bioclimatic atmospheres estimated from K, THI and pathologies in the department of Ouémé.

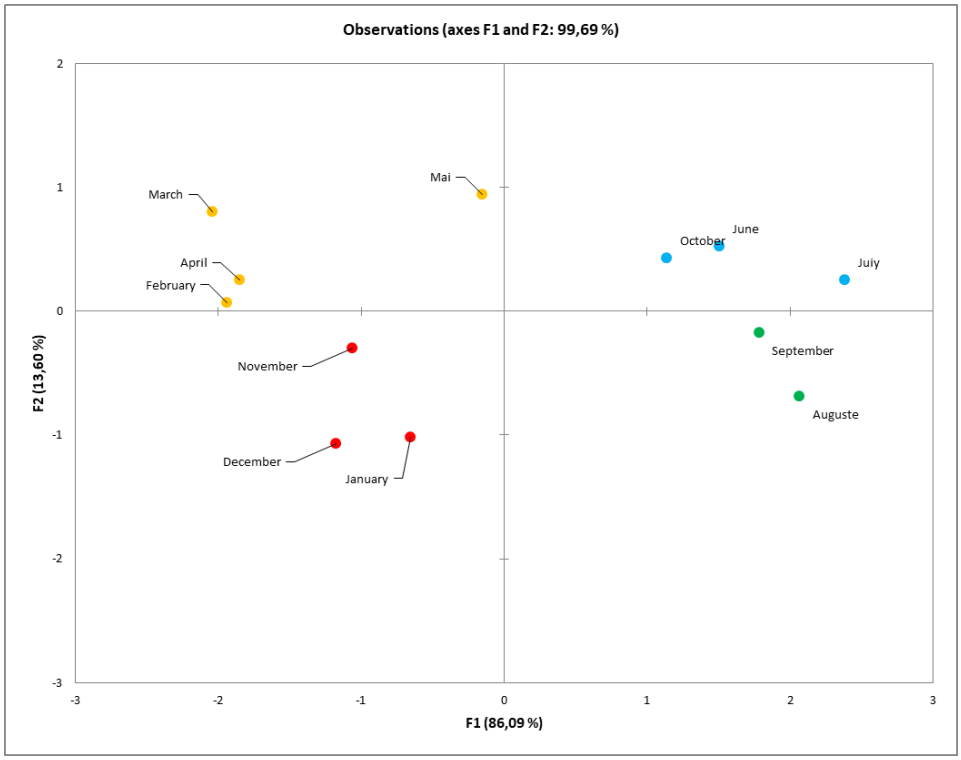

Figure 5: Unfavorable periods for malaria in the department Ouémé

Légende : : *Favourable period* : *Slightly favourable period*

: *Unfavourable period,* *Very unfavourable period*

Data Source: *2016 Calculation Results and ASECNA Data (2016)*

The analysis of figure 5 makes it possible to distinguish four (4) categories of favorable and unfavorable period for the malaria in the department of Ouémé. Indeed, the months of June, October, and July correspond to months of high prevalence of malaria cases in the department of Ouémé. These months also correspond to the month of rainy seasons in the department of Ouémé. At the same time, the months of August and September correspond to a period when the cases of malaria are slightly increasing in the department of Ouémé.

The periods or cases of malaria are low and very low are the months of January, February, March, May, April and November-December. From Figure 4, it can be noted that the adverse climatic and health periods for malaria-sensitive people take into account the months of June, July and October on the one hand and August and September on the other.

Figure 6 presents the climato-sanitary and ARI periods in the department of Ouémé.

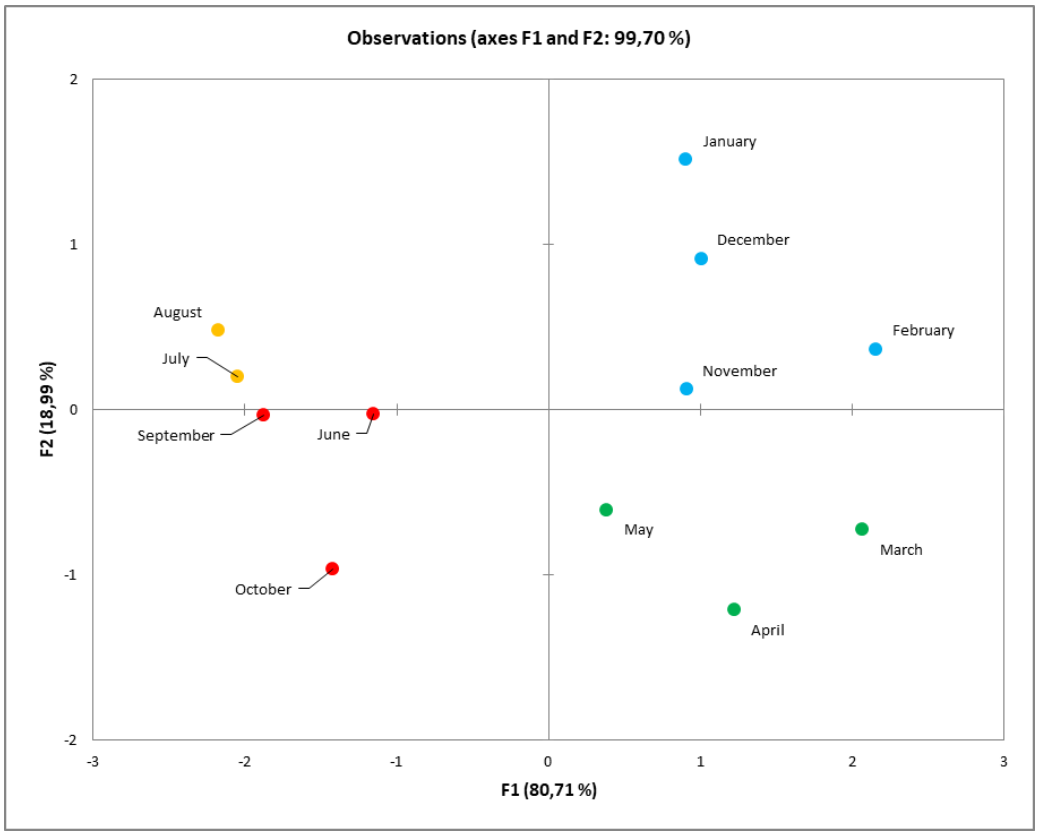

Figure 6: Unfavorable periods for ARI in the department Ouémé

Légende : ●*: Favourable period* ●*: Slightly favourable period*

●*: Unfavourable period,* ●*Very unfavourable period*

Data Source: *2016 Calculation Results and ASECNA Data (2016)*

The analysis of figure 5makes it possible to distinguish four (4) categories of favorable and unfavorable periods for ARI in the department of Ouémé.

The first category of period is the favorable period for the occurrence and recrudescence of ARI cases in the department of Ouémé. This period takes into account the months of January, February, November and December. These months are the months of harmattan and dry season. These results correspond to those of

Azonhè (2014) in a similar ecosystem.

The second category of period is the period where the number of cases of ARI is slightly increasing. These months (March, April and May) correspond to the beginning and the end of the rainy season in the department of Ouémé. The months of July, August furnish the third period category. These are months when ARI cases are rare. This confirms the results of work by Boko, (1992) and Houssou et al, (2006)

Finally, we find the months of June, September and October in the last and fourth category of climato-sanitary period. In this category, cases of ARI are almost non-existent in the department of Ouémé. This is due to the atmospheric configuration of these months (Mehinto-Dovonou, 2015).

It should be remembered that whatever the category, bioclimatic environments are not demanding throughout a year.

5. Discussion

Bioclimatological studies based on the Houssou et al. (2010) air-cooling index (K) confirm the values obtained here. Indeed, the authors worked on the south-west of Benin which takes part of the department of Ouémé. At the same time, Boko et al (2014), who have been working all over the Beninese southern coastal area, found similar results with a few exceptions because of the thermohygrometric index which according to Boko (2014) is influenced by the high humidity recorded in the level of the Cotonou station. Indeed, the proximity of the Cotonou Station to the sea makes the humidity values are higher. What can skew the thermal sensation of squi populations are more of the coast.

As for favorable periods for malaria, it turned out that June, July and October are the most favorable for prevalence. this is confirmed by de Boko (1988), Cl édjo (1993), Houssou et al., 2006) and DATE (2015) who have worked in similar environments.

And in the same vein, the favorable periods for the prevalence of ARIs are January, February, November and December. This is confirmed by Boko (1992) Houssou et al. (2006) and Mehinto-Dovonou (2015). Indeed these months favor for a high rate of prevalence. The K oscillates for these months in the range of 80 - 125 Kcal.

6. Conclusions

Climate is a defining attribute for the health of populations. Thanks to the bioclimatic indices (K and THI), which combine the parameters of temperature, humidity, sunshine and wind, the climatic comfort level of the study environment is determined. Thus from the foregoing, the most unfavorable

climato-sanitary periods are the dry seasons in the department of Ouémé in Benin.

The results obtained make it possible to conclude that the bioclimatic atmospheres being in general to the discomfort, one can expect a recrudescence or increase of the pathologies infantile related to the climate. It is therefore necessary that the authorities at various levels can take appropriate measures by early warning systems to help people in the department of Ouémé.

Acknowledgment

Thanks for the collaboration of the Doctors Fidèle MEDEOU and Roméo KADJEGBIN for the differents corrections and professor Ernest AMOUSSOU for reviewing this paper.

References

[1]. Afouda F., (1990). *Water and Crops in Central and Northern Benin: A Study of the Variability of Water Balances in their Relations with the Middle of the African Savannah*. Doctorate thesis new regime, Paris IV, Sorbonne, 428p.

[2]. Ahoton C., (2013). *Environmental Parameters and Prevalence of Acute Respiratory Infections in the Municipality of Pobe*. Master's degree in Geography DGAT / FLASH; University of Abomey-Calavi; 92 p.

[3]. Amoussou E., (2010). *Rainfall variability and hydro-sedimentary dynamics of the catchment basin of the Mono-Ahémé-Couffo fluvio-lagoon complex*. PhD thesis, University of Burgundy, Dijon, France, 315 p.

[4]. Azonhè T. H. S. N. (2014). Environmental Conditions of Diseases of Children Under Five in Ouinhi Commune, J. *Rech. Sci. Univ. Lome (Togo)*, 2014, Series B, 16 (2), pp. 139-150

[5]. Baparapè, (2012). *Bioclimatic factors and health of children from 0 to 5 in the municipality of Malanville*, Memory of Geography, UAC, 92 p.

[6]. Besancenot J.-P., (2001). Climate and Health, Imprimerie des Presses Universitaires de France, 127 p.

[7]. BioKlima © 2.6., Software package, http://www.igipz.pan.pl/Bioklima-zgik.html

[8]. Boko M. (1992). type of weather and respiratory tract disease in children in outlying areas of Cotonou (Benin, West Africa) Pathological risk, climatic rhythms and paroxysms. *Ed. John Libbey. Eurotext*, 1992, pp. 279-286

[9]. Boko M., (1988). Climates and rural communities in Benin: climatic rhythms and development rhythms. Ph.D. thesis, University of Burgundy, Vol I and II, Dijon, UA 909, CNRS, 607 p.

[10]. Boko N. P. M., (2014). *Bioclimates and tourism in the coastal areas of Benin (West Africa)*, PhD thesis in geography, University of Abomey-Calavi (UAC-Benin), 245 p.

[11]. Boko NPM, Medeou F., Vissin E., Houssou CS and Blaŝejczyk K., (2014). Characterization of bioclimatic

atmospheres in the coastal towns of Benin (West Africa), Conference Act, XXVIIth Colloquium of the Association International Climatology, Dijon, pp. 605-611.

[12]. Clédjo P.F.G.A., (1993). Hydroclimatic and pathological rhythms in lacustrine environment: Sous -Préfectures of Sô-Ava and Aguégués; Master's thesis, DGAT / FLASH, UNB; 149 p.

[13]. Dated A.C., (2015). Bioclimatic factors and health of children from 0 to 5 years in the commune of Dassa-zoumè, memory of mastery, DGAT / FLASH / UAC; 94 p.

[14]. Gandonou J., (1993). Biometeorological environment and diseases of the respiratory tract and lungs in Benin: the case of the Cotonou agglomeration. Master's degree in geography, UAC. 102 p.

[15]. Ganem Y., Meyer J.P., Luzeaux N. and Brasseur G., (2004). Thermal environments: Work during periods of hot weather. In Document for the Labor Physician, 97, pp. 51-68.

[16]. Gbedekoun S. L., (2011). Contribution to the geography of health in the Commune of Houéyogbé. Master's degree in geography, UNB, Abomey-Calavi, 100 p.

[17]. Handschumacher P., (1992). Health as a marker of the environment? Proceedings of the symposium on the environment in the teaching of the human and social sciences. Dakar UCAD 25, 26 and 27 November, pp. 103-114.

[18]. Houssou C. S., Vissin E.W., (2005). Type of time and pathology in the urban district of Kandi (Benin, West Africa), proceedings of the AIC symposium, pp. 272-275.

[19]. Houssou C.S. Vissin E. and Perard J., (2006). Climatic variability and pathology in the department of Mono (Benin, West Africa). in Conference Act AIC XIX. September, pp. 316-321.

[20]. Houssou S. Ch., (1998). The human bioclimates of Atacora (North-West Benin) and their socio-economic implications. Unique thesis of geography, Dijon 332 p.

[21]. Houssou C. S., Clédjo P.F.G.A. And Ogouwalé E. (2010). Bioclimatic Atmosphere in the South-East Coast of Benin (West Africa), Journal of Geography of Benin University of Abomey-Calavi (Benin) N °8, December 2010, pp. 3-18

[22]. Jarraya M., (2012). "Cold Environments and Respiratory Consultations in the Public Health Sector in Sfax (Tunisia)", *Cybergeo: European Journal of Geography* [Online], Environment, Nature, Landscape, Document 585, Implemented line on January 30, 2012, accessed March 29, 2013. URL: http://cybergeo.revues.org/25032;DOI:10.4000/cybergeo.25032

[23]. Kalkstein L. S., (2001). Biometeorology: A Study of the Linkages of Time, Climate and Health, in *WMO Bulletin*, Vol. 50, No. 2, pp. 147-154.

[24]. Médéou F., (2015). *Biometeorological ambiences and farmers' health vulnerability in the context of climate*

change in the Department of the Hills. PhD Thesis, EDP / FLASH / UAC, 208 p.

[25]. Mehinto-Dovonou F. (2015). Effects of bioclimatic factors on the health of children from 0 to 5 years and sustainable development in the Municipality of Porto-Novo, Master's thesis II, University of Abomey-Calavi, 89 p.

[26]. WHO (1990). *Potential Health effects of climate change: report of WHO task group*. WHO / REP / 90, Geneva, Switzerland, 58 pages.

[27]. Thom E., (1959). "The discomfort index", *Weatherwise*, No. 12, pp. 57-60.

[28]. Vitouley N., (2015). Bioclimatic factors and health of children from 0 to 5 years in the municipality of Glazoué, Master's thesis, DGAT / FLASH / UAC; 112 p.

[29]. Yaka P., (2009). Climate change and meningitis: "Towards an extension of endemic areas" Sahel Sciences, n ° 16, pp 3-4.

[30]. Yaka P., Sultan B., Janicot S., Broutin H., Fourquet N. and Philippon S., (2008). Relationships between climate and year-to-year variability in meningitis outbreaks: A case study in Burkina Faso and Niger, International Journal of Health Geographics 2008.