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Research Article

# Modelling of Some Physical-Chemical Parameters of the Bikoro Peat Bogs in the Congo Basin in the North-West of the Democratic Republic of Congo

**Faustin Ilanga Onzeli[1], Lydie Mooto Ilanga[2], Evariste Kazadi Tshiamala[3], Albert Kabasele Yenga Yenga[3, 4], Crispin Ngoma Buveka[3, 5, 6, *]**

[1]Department of Physics and Technology, Higher Pedagogical Institute of Mbandaka, Mbandaka, The Democratic Republic of Congo

[2]Department of Environment and Sustainable Development, Higher Institute of Rural Development of Mbandaka, Mbandaka, The Democratic Republic of Congo

[3]Department of Physics and Applied Sciences, National Pedagogical University, Kinshasa, The Democratic Republic of Congo

[4]Department of Spatial Remote Sensing, National Pedagogical University, Kinshasa, The Democratic Republic of Congo

[5]Department of Electromechanics, University President Joseph Kasa - Vubu, Boma, The Democratic Republic of Congo

[6]Nuclear Safety Department, National Committee for Protection against Ionizing Radiation, Kinshasa, Democratic Republic of Congo

## Abstract

This study, carried out in the heart of one of the world's most important wetlands, focuses on the modelling of certain physico-chemical parameters of the Bikoro peat bogs in the Congo Basin in the north-west of the Democratic Republic of Congo. To this end, we have characterized the above-mentioned parameters using digital modeling based on satellite and in situ data from five villages that make up the three sectors of this territory. Some of the equipment used includes three GPS (Garminextrex 30), Cybertacker v3.435 on Android, cameras (Samsung Wifi 12x + GPS), passive sensors (Radar). We also used an infrared spectrophotometer. The main results in relation to the 240 samples taken show that the pH of the peat bogs in the Bikoro territory varies between (2.600 ±0.001) and (5.000±0.004), the electrical conductivity measured varies between [85.48±3.17] µS/cm and [97.99±5. 47] µS/cm, the experimental carbon rate reported in tonnes per hectare is 135.3021, the forest carbon stock derived from WWF LiDar is 137.1484 and the spatial distribution of the temperature of these peatlands indicates that it ranges between (22.39 ±1.05) ℃ and (24.79 ±1.95) ℃. The results of this study show that the peat bogs in the Bikoro area are wetlands that are both significantly acidic and carbon sinks.

## Keywords

Peatland, Experimental Carbon Rate, Carbon Stock, Peatland Ph, Conductivity, Electric

*Corresponding author: crispin.ngoma@upn.ac.cd (Crispin Ngoma Buveka)

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# 1. Introduction

Peatlands are wetlands [1-4] accumulating a significant quantity of organic matter under a thickness of at least 30 cm at several meters depth [5]. The Bikoro peatlands are located in the Central Bowl which is itself located in the center of the Congo Basin. It is the second largest tropical wetland in the world [6-10] and is therefore the largest complex of tropical peatlands [11-13].

At a time when the fight against climate change [14-16] represents ongoing news, it is established that forests and peatlands are two main carbon sinks. Although numerous studies have since been carried out on forests, research on peatlands has not yet seen the same investment. Recent research has established that peatlands help maintain climate stability and prevent the drift of climate change showing the roles and implications of peatlands in the complete carbon cycle [17]. Despite this, the Congo Basin forest is subject to anthropogenic degradation and the peatlands in the Bikoro territory are also victims.

As such, tropical peatlands, which are among the most carbon-rich ecosystems on the planet [18] and whose the dynamics of water storage strongly controls these carbon stocks and deserve increasing attention. And as disturbed peatlands represent a significant potential source of $CO_2$ and $CH_4$ in the atmosphere [5], this study seeks to establish whether the carbon stocks in this peatland are stable, or if they are vulnerable to disturbances induced by actions anthropogenic or by climate change [19-21]. To do this, we analyze the possible threats to the stability of peatland carbon reserves in the Bikoro territory and consider more generally the threats to the integrity of these ecosystems in order to evaluate the protective measures to be taken into account. put in place to minimize threats.

The main objective of this study is to assess the state of the Bikoro peatlands with a view to encouraging their preservation from human anthropic activities leading to their alteration.

# 2. Material and Methods

## 2.1. Study Environment

### 2.1.1. Representation of the Study Environment

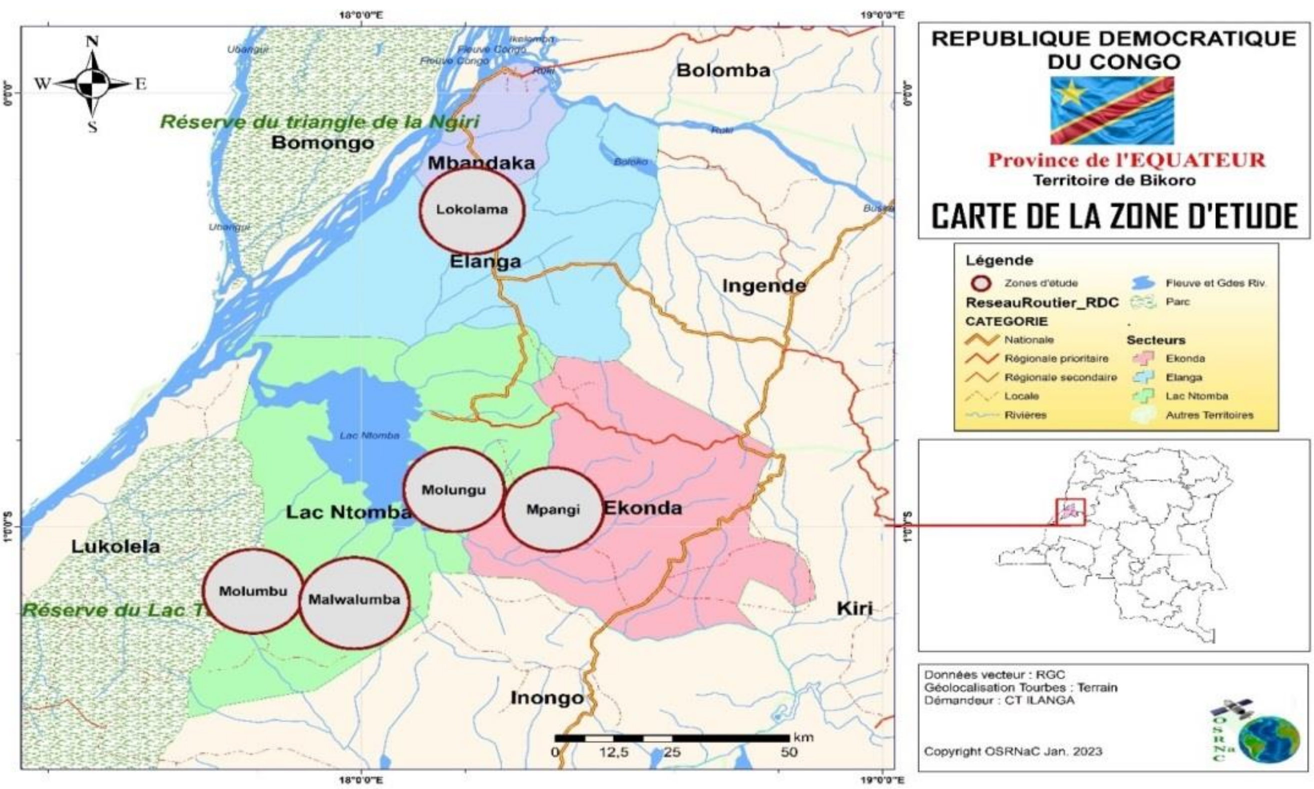


***Figure 1.*** *Map of the study area (Source: spatial remote sensing laboratory (OSRNac) UPN, 2022.*

*Figure 2. Taking peat cores in the locality of Lokolama, Elanga sector – Bikoro territory.*

We conducted our study in the territory of Bikoro located in the north of the Democratic Republic of Congo, 128 km from the city of Mbandaka in the Province of Equateur. The three sectors that make up the Bikoro territory were affected. We selected five localities based on their forest densities in the study area: Lokolama, Molungu, Molumbu, Malualumba and Mpangi.

### 2.1.2. Presentation of Samples

Table 1 presents the geographic coordinates of different sampling sites for the 240 peat samples from the Bikoro territory.

*Table 1. Geographic coordinates of peat sample extraction sites.*

| Territory / Locality | Altitude | Latitude - S | Longitude - E |
|---|---|---|---|
| Bikoro | 450 m | 00 °43'40 " | 18 °07'58" |
| Lokolama | 314 m | 00 °17'59.1 " | 018 °012'16.6" |
| Molungu | 311 m | 00 °59' 12.4" | 018 °012' 22" |
| Mpangi | 329 m | 00 °57' 00.7 " | 018 °22' 54.0" |
| Molumbu | 313 m | 01 °09'45.7 " | 017 °50'10.3" |
| Malwalumba | 318 m | 1 °11'09.8 " | 017 °51'07.1" |

## 2.2. Material

For studying the parameters physico chemical retained in this study, the basic materials which have summer used are: three GPS (Garminextrex 30), Cybertacker v3.435 on Android, field notebook (Forestrysuppliers), cameras (Samsung Wifi 12x + GPS), files, two motorcycles. Passive sensors (Radar), an infrared spectrophotometer, a LAPTOP computer, software: NOAA, NOAH, Arc GIS, MATLAB and ERDAS, Excel, a graduated marker, a PVC tube, a tape measure (250 m), a machete, a 950.75 $cm^3$ container, marked black bags, a pH meter, a thermometer with cobra sensor, peat cores of different sizes localities of the three sectors that make up the territory of Bikoro have summer used in the laboratory. We have previously used ARCGIS 10.4 software to delimit the trace along which the samples have summer taken.


*Figure 3. pH meter (A), GPS (B), compass (C) and precision balance (D) used in this study.*

## 2.3. Methods

After having demarcated a 6 km route along a track on which the samples were taken, we identified in each transect any plant species that characterize the beer tower. The geographic coordinates were taken from the different extraction points of 240 peat samples where the different sampling points were respectively 250 m apart. At each point, we introduced the PVC into the peat until reaching a depth of 2 or 3.5 m to extract the sample from the peat. The mass of wet peat will be compacted to expel the water trapped in the core sample before being weighed on a precision balance, and all data were entered into an Excel sheet.

These data allowed us to quantify the carbon stock of peatlands at the ISP/Mbandaka Biology Laboratory. We determined the degree of humification by the spectrophotometer and measured the sodium pyrophosphate index [22]. The physical measurements carried out in the peat bog complied with the statistical requirements required in physics [23-25] and to know the level of carbon in the soil, the dosage of organic carbon was made possible thanks to Anne's method, the oxidation of which takes place at 97.6%

[26].

$$C\%\ en\ g = \frac{0{,}615\ x\ (N-n)\ x\ 100}{P\ x\ 1000} \quad (1)$$

Lokolama peatlands [27], we resorted to taking measurements in the field on the one hand and to observations of radar data.

# 3. Results and Discussion

## 3.1. Results

### 3.1.1. Modeling Digital Parameters Physico-chemical of Bikoro Peatlands

Table 2 presents the minimum, maximum, average and deviation of the physical variable principles of the 240 samples taken from the different sites in the Bikoro territory.

***Table 2.*** *Indicators of physical measurements in the Bikoro peatlands.*

| Setting physicochemical | N | Minimum | Maximum | Mean | Std. DETOUR |
|---|---|---|---|---|---|
| In Situ Depth Peat in meters | 240 | 0.00 | 3.00 | 2.3846 | 0.37935 |
| In situ Mass Peat wet (gram) | 240 | 1062.00 | 10655.0000 | 1289.901667 | 1337.9956270 |
| Mass of water extracted from peat (gram) | 240 | 122.90 | 9730.50 | 358.8135 | 1337.70329 |
| In Situ peat mass dry (gram) | 240 | 891.00 | 958.0000 | 931.088167 | 11.1174826 |
| In Situ Temperature Peat in ℃ | 240 | 22.40 | 25.60 | 23.7981 | 0.90208 |
| In Situ Air Temperature in ℃ | 240 | 24.50000 | 30.00000 | 26.8158333 | 1.7487874 |
| In Situ pH Peat | 240 | 2.60000 | 5.00000 | 3.7883333 | 0.72481806 |
| In Situ Clarity – Energie Lux | 240 | 404.0000 | 781.0000 | 511.772500 | 92.2733527 |
| In Situ Relative Air Humidity % | 240 | 60.2000 | 79.0000 | 71.546667 | 3.7737019 |
| In Situ conductivity Electrical (g/µSec/cm) | 240 | 78.9000 | 885.1600 | 101.819667 | 73.1688237 |
| In Situ Density Peat dry ($g/cm^3$) | 240 | 0.84 | 1.04 | 0.9379 | 0.06306 |
| In Situ Density Peat Hum ($g/cm^3$) | 240 | 1.05 | 11.21 | 1.1701 | 0.84928 |
| In Situ Density Peat dried | 240 | 0.0008880000 | 0.0010000000 | 0.0009755583 | 0.0000449479095 |
| In Situ Density Peat Humid | 240 | 0.001000000 | 0.00110000 | 0.0010889000 | 0.00002378157228 |
| In Situ rate C experimental Peat in t/ha | 240 | 18.54 | 61.25 | 45.1007 | 10.05241 |
| WWF LiDAR Forest Carbon stock in t/ha | 240 | 4.89 | 155.64 | 137.1484 | 21.34300 |
| Carbon rate exp Reported in t/ha to the Territory | 240 | 55.62 | 183.75 | 135.3021 | 30.15723 |
| Satellite ppm daily t $H_2O$/ha | 240 | 0.09257 | 9.26686 | 3.1387612 | 2.62299303 |
| NDVI Biomass Satellite | 240 | 78.020000 | 83.650000 | 81.08625000 | 2.025318018 |
| Satellite Tmoy Air in ℃ | 240 | 25.460000 | 30.010000 | 28.46542083 | 1.042460199 |
| groundwater reserve in t$H_2O$ | 240 | 503.6710 | 558.2070 | 519.730358 | 13.2150564 |
| Valid N (listwise) | 240 | | | | |

The results in Table 3 reveal that wet peat temperature and pH decrease with wet peat mass.

***Table 3***. *Variation in pH of peatlands in the Bikoro Territory.*

| Model | | Unstandardiz Coefficients | | Standardized Coefficients | Sig |
|---|---|---|---|---|---|
| | | B | Std Error | Beta | |
| 1 | (Constant) | 1831.386 | 3478.971 | | 0.050 |
| | In Situ Temperature Peat in ℃ | -20.158 | 128,149 | -0.014 | 0.048 |
| | In Situ pH Peat | -16.301 | 159,489 | -0.009 | 0.042 |
| 2 | (Constant) | 1564.097 | 2289.604 | | 0.50 |
| | In Situ Peat Temperature in ℃ | -11.22 | 96.141 | -0.008 | 0.049 |

Table 4 shows that conductivity is proportional to precipitation and inversely proportional to water table and wet peat density.

***Table 4.*** *Electrical conductivity of the Bikoro peatland.*

| Model | | Unstandardiz Coefficients | | Standardized Coefficient | Sig |
|---|---|---|---|---|---|
| | | B | Std Error | Beta | |
| 1 | (Constant) | 182,576 | 190,649 | | 0.034 |
| | Groundwater Reserve in tH $_2$O/ha | -0.168 | 0.368 | -0.030 | 0.065 |
| | InSitu Density peat Wet (g/cm$^3$) | -1.192 | 5,590 | -0.014 | 0.083 |
| | Satellite PPmm daily tH $_2$O/ha | 2,512 | 1,854 | 0.090 | 0.018 |

The Table 5 indicates that there is a comparison between the satellite Lidar results which have an average value of 137.1484 tonnes per hectare and the in situ experimental result which has an average value of 135.3021 tonnes per hectare.

***Table 5***. *Experimental carbon stock in the Bikoro territory.*

| | | Statistics | Bootstrap has | | |
|---|---|---|---|---|---|
| | | | Std. Error | 95% Confidence Interval | |
| LEED UNIVERSITY WWWF LIDAR Forest Carbon stock in ton /ha | N | 240 | 0 | 240 | 240 |
| | Minimum | 4.89 | | | |
| | Maximum | 155.64 | | | |
| | Mean | 137.1484 | 1.3353 | 134.3399 | 139.6237 |
| | Std. DETOUR | 21.34300 | 2.51858 | 16.11291 | 25.85478 |
| Experimental Carbon Rate Reported in ton /ha in the BIKORO Territory | N | 240 | 0 | 240 | 240 |
| | Minimum | 55.62 | | | |
| | Maximum | 183.75 | | | |
| | Mean | 135.3021 | 1.9124 | 131.4503 | 138.9079 |
| | Std. DETOUR | 30.15723 | 1.58807 | 26.96900 | 33.18256 |
| Valid N (listwise) | N | 240 | 0 | 240 | 240 |

The Table 6 shows how the peat bog influences its temperature.

***Table 6.*** *Influence of peat bog temperature on ambient air.*

| Model | | Unstandardiz Coefficients | | Standardized Coefficients | Sig |
|---|---|---|---|---|---|
| | | B | Std Error | Beta | |
| 1 | (Constant) | -8.394 | 1,915 | | 0.000 |
| | In Situ Temperature Peat in ℃ | 1,480 | 0.080 | -766 | 0.000 |
| 2 | (Constant) | -6.020 | 2.136 | | 0.005 |
| | In Situ Peat Temperature in ℃ | 1.328 | 0.101 | 0.688 | 0.000 |
| | In situ clarity Energy Lux | 0.002 | 0.001 | -127 | -0.017 |

Table 7 shows the influence of peat temperature on seasonal precipitation.

***Table 7.*** *Action of peat bog temperature on precipitation.*

| Model | | Unstandardiz Coefficients | | Standardized Coefficients | Sig |
|---|---|---|---|---|---|
| | | B | Std Error | Beta | |
| 1 | (Constant) | -9.364 | 4,552 | | 0.041 |
| | In Situ Temperature Peat $^0$ Celsius | 1.030 | 0.286 | 0.354 | 0.000 |
| | In Situ Temperature Air $^0$ Celsius | -0.448 | 0.148 | -0.297 | 0.003 |

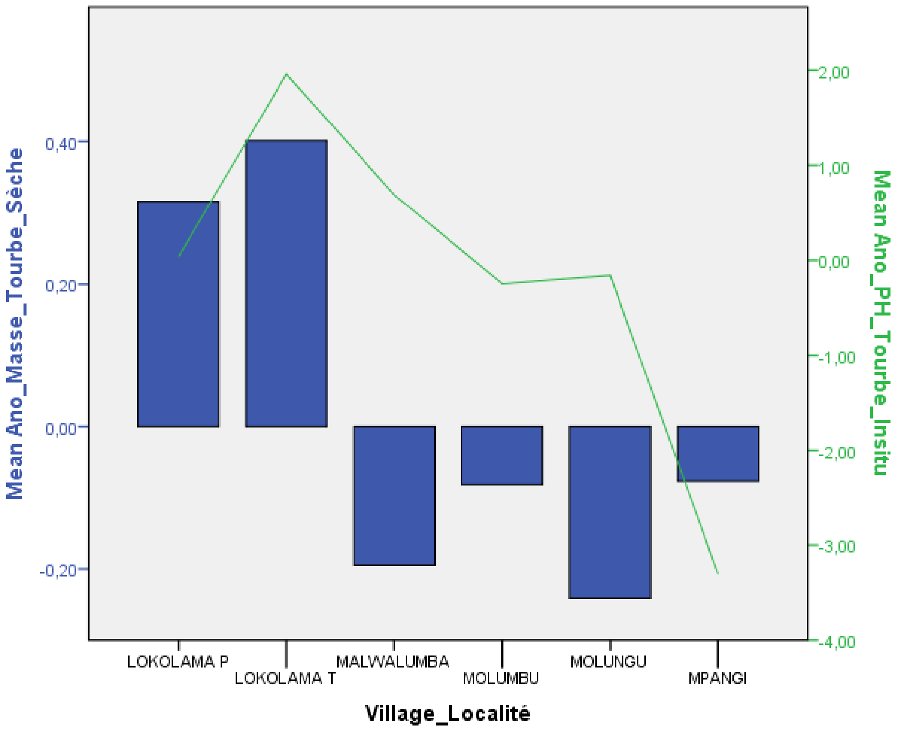


***Figure 4.*** *Dry peat mass and in situ peat pH.*

The Figure 4 above shows the appearance of the pH according to the data collection sites.

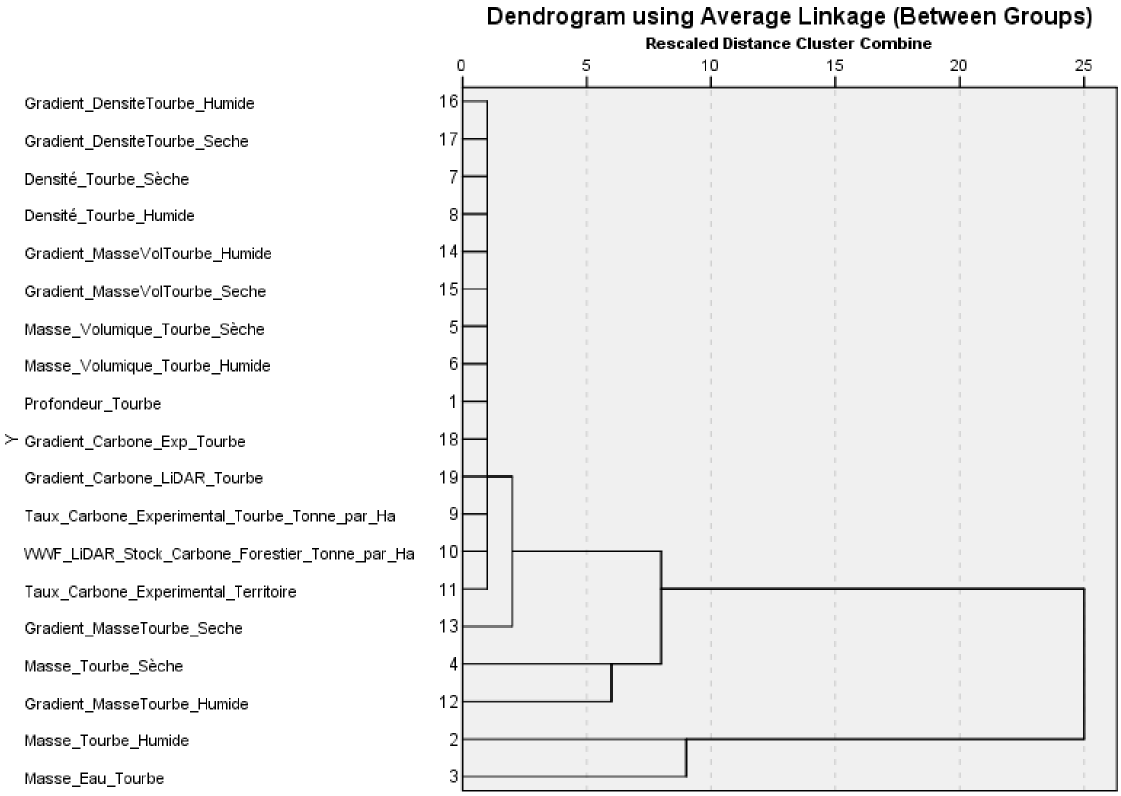


***Figure 5.*** *Correlation diagram between variables measured in situ and WWF Lidar data.*

The Figure 5 indicates that there is a Euclidean rapprochement and validation between the variables measured in situ and the Satellite LiDAR data from the WWF Project.

## 3.1.2. Modeling Spatial Parameters Physico Chemicals of the Bikoro Peatland

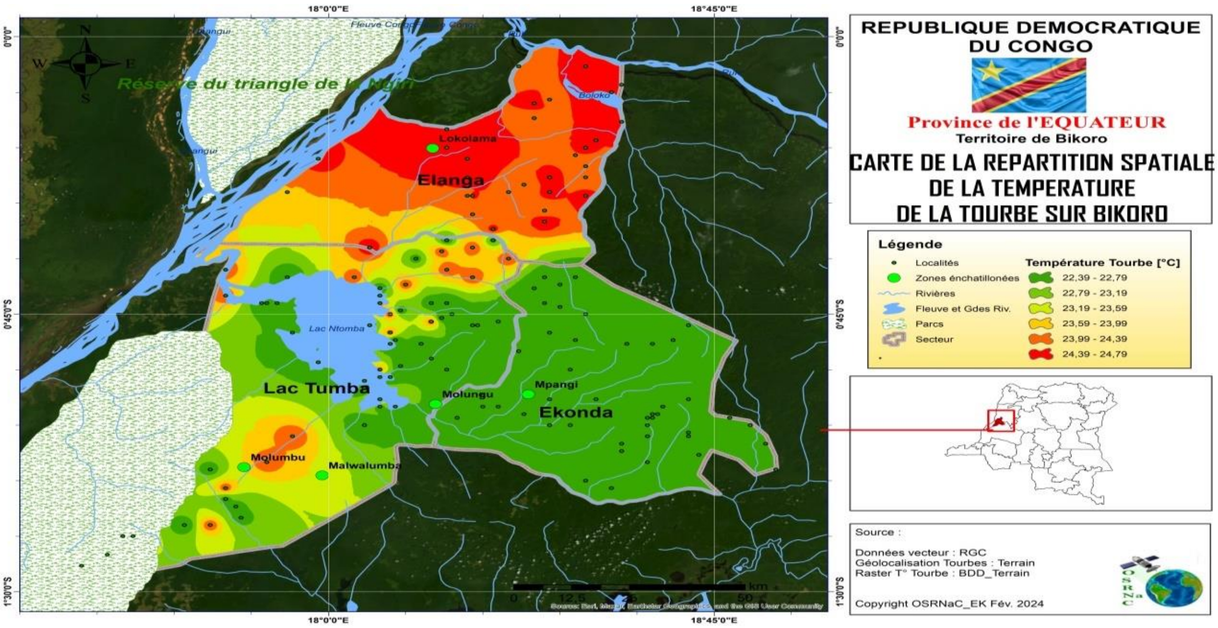


***Figure 6.*** *Spatial distribution of peat bog temperature on Bikoro.*

The Figure 6 presents the spatial distribution of peat temperature in the Bikoro territory.

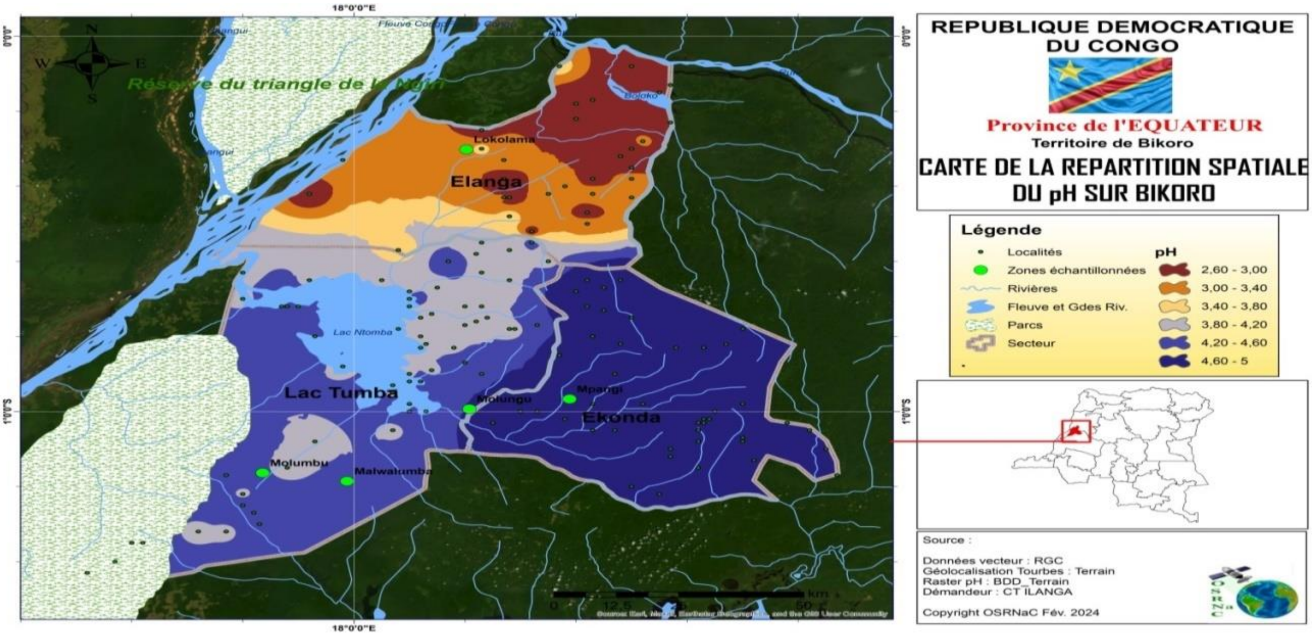


***Figure 7**. Spatial distribution of pH in the Bikoro Territory.*

The Figure 7 above shows the spatial distribution of pH.

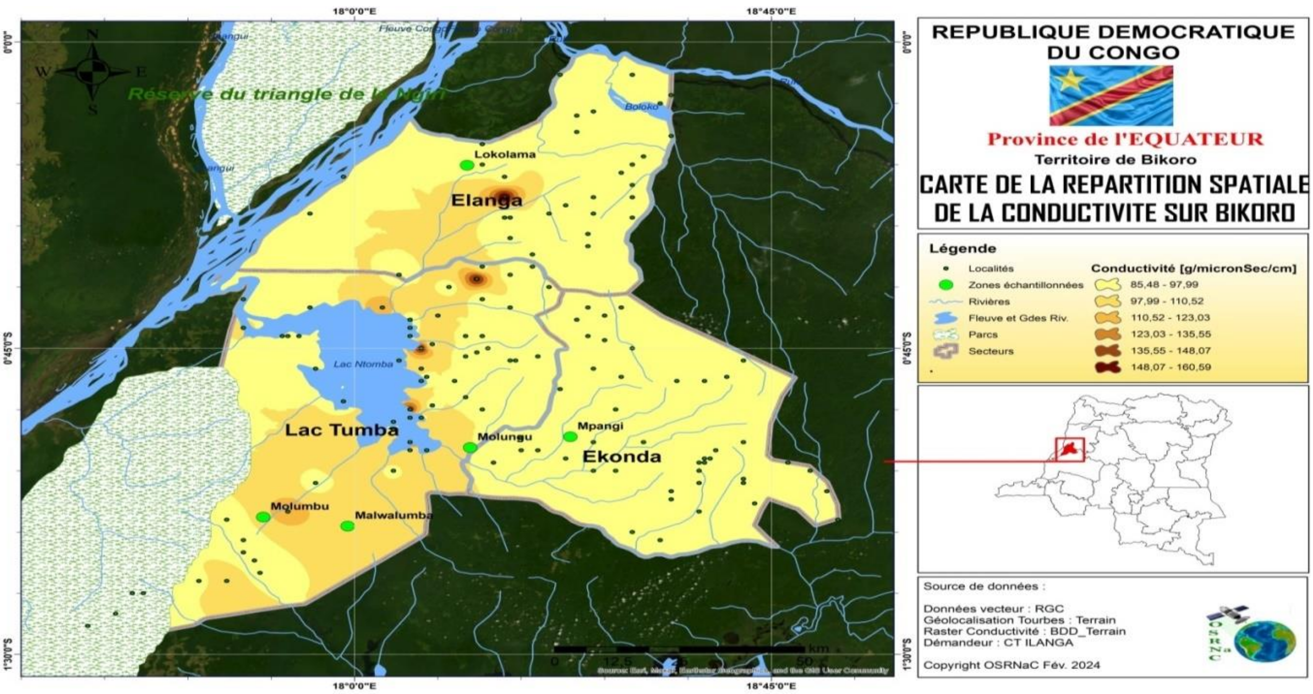


***Figure 8**. Spatial distribution of electrical conductivity on Bikoro.*

The Figure 8 indicates the spatial distribution of electrical conductivity in the Bikoro territory.

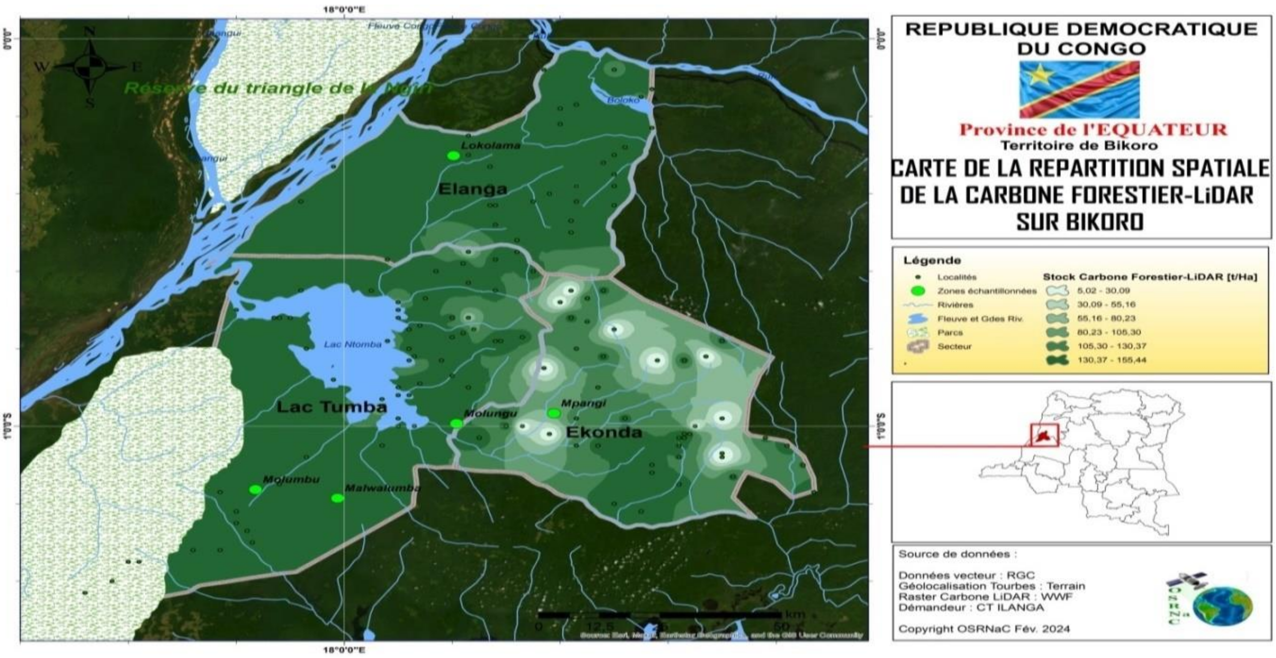


*Figure 9*. *Spatial distribution of forest carbon rate Lidar on Bikoro.*

The Figure 9 indicates that the Bikoro Territory has a large forest biomass.

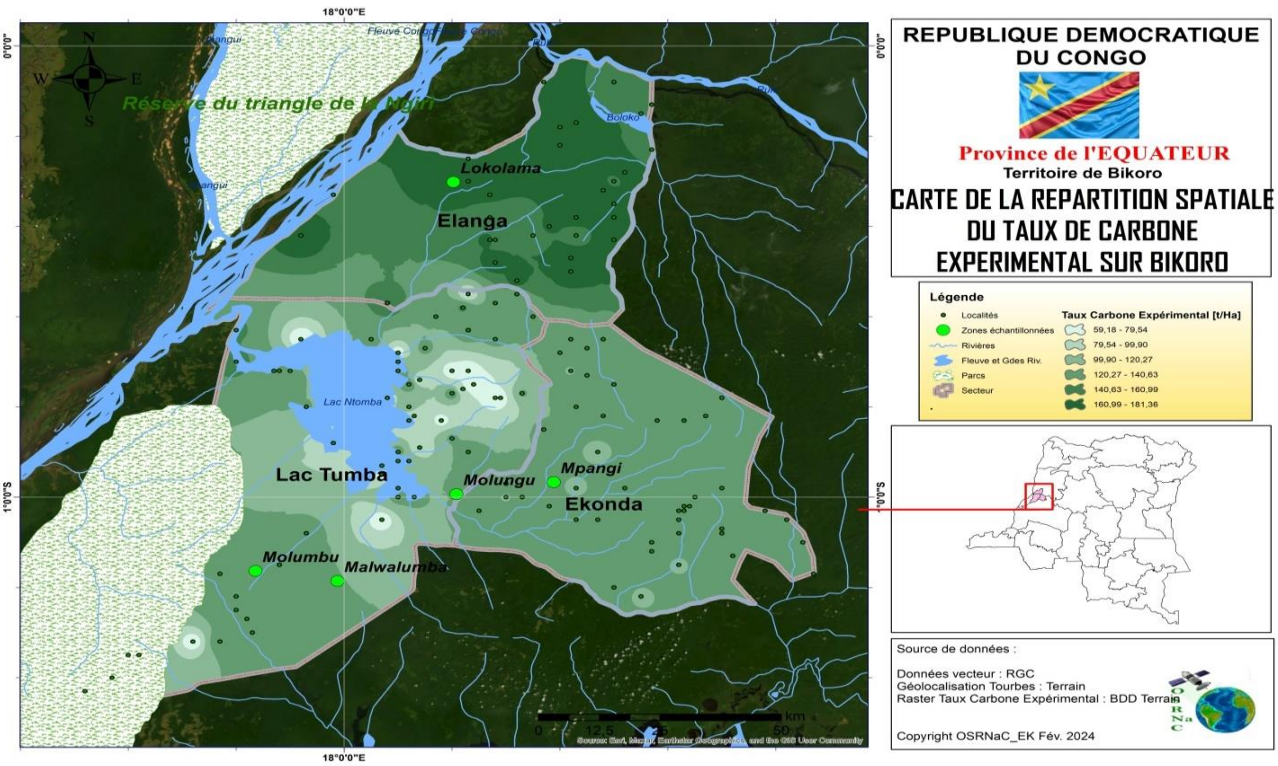


*Figure 10*. *Spatial distribution of the experimental carbon rate on Bikoro.*

The Figure 10 makes it possible to compare the variables measured, in situ, on the 240 sites selected in this study and the Satellite LiDAR data from the WWF Project.

### 3.2. Discussion

In this part, we will compare the results that we obtained with other results published in studies carried out not very long ago by other researchers.

### 3.2.1. Indicators of Physical Measurements in One of the Sectors of the Bikoro Territory

The measurements collected according to usual physics practices [23-25] reveal indicators which corroborate results obtained in previous studies both in the DRC [6, 27] and in other parts of the world and which reflect their positive influence on the local climate [28, 29].

### 3.2.2. Variations in Peatland pH in the Bikoro Territory

The pH of the peat in the Bikoro territory varies tween $(2.600 \pm 0.001)$ And $(5.000 \pm 0.004)$. The appearance of this pH as a function of the data sampling sites shown in Figure 7 clearly shows that the pH is less than 5 in all sites, which clearly indicates that the Bikoro peatlands remain an acidic environment whatever she be a wet blanket. These values are typical of undisturbed peatlands which are close to certain values obtained during previous research in Canada [30].

### 3.2.3. Conductivity Electricity from the Bikoro Peat Bog

Soil electrical conductivity involves measuring the ions in the sample. The values of electrical conductivity recorded in the Bikoro territory vary between$[85.48 \pm 3.17]\ \mu S/cm$ and $[97.99 \pm 5.47]\ \mu S/cm$. In accordance with research these values clearly indicate a link between electrical conductivity, pH and temperature fluctuations [28, 31].

### 3.2.4. Estimation of the Experimental Stock of the Bikoro Peatland Compared to LIDAR Data

The evaluation of the experimental stock, in situ, of the carbon stock is 135.1484tonnes per hectare while the satellite Lidar data returns an average value of137.1484 $t/ha$. This result shows that this carbon stock is not negligible and its preservation deserves increased monitoring to ensure possible threats to which this peatland could be exposed. [32] in view of what it represents in terms of carbon [33, 34].

### 3.2.5. Influence of Bog Temperature on the Air Ambient

The results of the variation in precipitation data indicate that the precipitation trend is slightly negative in places, particularly in the Lokolama area. These results are corroborated by studies which attest that the quality of the peat bog symbolized by its humidity influences rainfall [35]. This observation is consistent [36] with the good condition of these peatlands, without obscuring the need to attract the attention of stakeholders to environmental protection given the fact that peatlands contribute to the ecosystem and climate regulation [37]. The results in Table 3 also reveal that wet peat temperature and pH decrease with wet peat mass. This table explains that the dense Lokolama Bog is more acidic than the less dense Molungu and Mpangi peatlands [27].

### 3.2.6. Distribution Spatial Temperature of the Bog on Bikoro

The Figure 6 that represents the spatial distribution of the temperature of the peat in the territory of Bikoro, indicates that this temperature is between, on the iDW classification, is between$(22.39 \pm 1.05)^{\circ}\mathrm{C}$ And $(24.79 \pm 1.95)^{\circ}C$. This result obtained is in agreement with some previous works [38-40].

### 3.2.7. Distribution Spatial pH in the Bikoro Territory

The Figure 7 indicates that the measurands of the pH value, in the iDW classification, are between 2.600 and 5.000 in accordance with the average of the measurements recorded in situ. This remarkable result confirms that the pH measurand in all the sampling sites of the 240 samples is less than 5, this confirms the fact that the peat bog in the Bikoro territory is an acidic environment [41, 42].

### 3.2.8. Distribution Spatial Conductivity on Bikoro

The examination of Figure 8 shows the spatial distribution of electrical conductivity on Bikoro, it appears from these data that electrical conductivity is included in the iDW classification interval of $[85.48, 160.59]$g/micronsec/cm which is low throughout the peat bog. of the Bikoro Territory. Which means that the circulation of electricity in the Bikoro peat bog is low and that the electrical conductivity has a negative effect on the NDVI which, in turn, has a positive effect on the electricity of the wet mass of the peat [43].

### 3.2.9. Distribution Spatial Carbon Rate Forest Lidar on Bikoro

The observation of Figure 9 indicates that the Bikoro Territory has a large forest biomass – Lidar given its dense forests. This is located in the iDW classification in the range of (5.02 at 155.44) t/ha. All sectors of the Territory have a dense forest which contributes to hosting tropical peatlands, the largest of which in the world are found in the Central Bowl depression, located in the Congo Basin and which stores 30.6petagrams of carbon [44-46]. On the other hand, this map shows that the Variables measured, in situ, on the 240 sites selected in this study and the Satellite LiDAR data from the WWF Project are not different except for a few details, particularly with regard to Carbon Masses. Peat on a scale of 1/25 between neural networks-9-10-11 [27].

### 3.2.10. Distribution Spatial Carbon Rate Experimental on Bikoro

The examination of Figure 10 i*ndicates that the experimental* *data on 240 sites and the* LiDAR data over the entire territory and the extensive experimental data on the field are as close as possible, like certain results published in other research [47, 48].

## 4. Conclusion

To ensure that the Bikoro peat bogs have an impact on climate stability, we conducted a study Modelling of Some Physical-Chemical Parameters of the Bikoro Peat Bogs in the Congo Basin in the North-West of the Democratic Republic of Congo. The results obtained show that the pH in the Bikoro territory varies between $(2.600 \pm 0.001)$ and $(5.000 \pm 0.004)$. The shape of this pH as a function of the electrical conductivity measured in the Bikoro territory varies between $[85.48 \pm 3.17]\ \mu S/cm$ and $[97.99 \pm 5.47]\ \mu S/cm$, These values indicate that the experimental in situ carbon stock is 3021tonnes per hectare, while satellite Lidar data indicate an average value of 137.1484 tonnes per hectare. The spatial distribution of peat temperature in the Bikoro area indicates that, according to the iDW classification, it ranges from $(22.39 \pm 1.05)$ ℃ and $(24.79 \pm 1.95)$ ℃.

Numerical modelling also showed that the average pH value in the iDW classification lies between $2.600$ and $5.000$, in line with the average of in situ measurements, and that the spatial distribution of Lidar forest carbon in Bikoro lies in the range $(5.02$ à $155.44)\ t/ha$ in the iDW classification. All these results indicate that the peatlands of Bikoro are still in good condition and contribute to climate stability.

## Abbreviations

| | |
|---|---|
| IDW | Intellectual Dark Web |
| LIDAR | Light Detection And Ranging |
| NDVI | Normalized Difference Vegetation Index |
| OSFAC | Acronym of Spatial Observatory of Central African Forests (in French) |
| OSRNaC | Acronym of Spatial Observatory of Natural Resources and Climate (in French) |
| pH | Potential Hydrogen |
| PVC | Poly-Chlorure of Vinyl |

## Conflicts of Interest

The authors declare no conflicts of interest.

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