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Climate variability and appearance of new plants: case of *Typha australis* in the Diaspora Valley (Niamey-Niger)

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Abstract: *The aspects that reflect the reality of climate variability appear in various forms across the globe. In West Africa and particularly in the Sahel, these are mainly recurrent droughts and floods. On land that is more and more open to vegetation, valleys appear, some of which are getting bigger from year to year, while in others, temporary or even permanent runoffs resurface. The Diaspora valley located to the west of Niamey, whose water resurfaced in July 2017 (latitude N 13 34.188 and longitude E 2. 01.794) following the heavy rains in June, has a flow that widens downstream. The change of biotope is characterized by the drying up of species that no longer tolerate enough humidity (Balanites aegyptiaca, Acacia Albida...) and the appearance of hygrophilous species (Typha australis, Ipomoea asarifolia...). Having a fast spreading ecology, Typha australis is colonizing the whole valley. In this ecosystem, the presence of Typha australis favours an increase in the concentration of certain soil chemical elements such as chloride (Cl-), calcium (Ca2+) and nitrate (NO3-) with 10132mg/l, 47.6mg/l and 5752 mg/l respectively). T.Australis had an effect on water quality by altering the calcium and resulting in high levels of bicarbonate (244mg/l) and pH (7.1). Through soil and water analyses and phyto inventory, this study seeks to analyse these new features of climatic variability in the Sahel.*
Keywords*: Niger - sahel - climate variability - Typha australis - valley*

Résumé
Les aspects témoignant la réalité de la variabilité climatique apparaissent sous diverses formes à travers le globe. En Afrique de l'Ouest et particulièrement au Sahel, il s'agit surtout des sécheresses et des inondations récurrentes. Sur des terres de plus en plus découvertes de végétations, apparaissent des vallées dont certaines s'agrandissent d'année en années, dans d'autres resurgissent des écoulements temporaires voire permanentes. La vallée Diaspora située à l'Ouest de Niamey dont l'eau est resurgie en juillet 2017 (latitude N 13 34.188 et longitude E 2. 01.794) suite aux fortes pluies de juin, présente un écoulement qui s'élargie en aval. Le changement de biotope se caractérise par l'asséchement des espèces ne tolérant plus assez d'humidité (Balanites aegyptiaca, Acacia Albida…) et l'apparition d'hygrophile (Typha australis, Ipomoea asarifolia..). Ayant une écologie de dissémination rapide, Typha australis est en train de coloniser toute la vallée. Dans cet écosystème, la présence de Typha australis favorise l'augmentation de la concentration de certains éléments chimiques du sol tels que le chlorure (Cl^-), le calcium (Ca^{2+}) et le nitrate (NO^{3-}) avec respectivement 10132mg/l, 47,6mg/l et 5752 mg/l. T.Australis a eu un effet sur la qualité de l'eau en altérant le calcium et entrainant le taux élevé de Bicarbonate (244mg/l) et du pH (7,1). Aux moyens d'analyse de sol, d'eau, d'inventaire phyto, cette étude cherche à analyser ces nouvelles particularités de la variabilité climatique au sahel.
Mots clés *: Niger - sahel - variabilité climatique – Typha australis –vallée*

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I. Introduction

Climatic anomalies in the Sahelian space since the 1970s have greatly influenced precipitation. Several studies have dealt with the long-term analysis of rainfall[1-5]. Interannual accumulation deficits, repositioning of isohyets towards southern positions and droughts are the main results of this work. Other researchers have focused on the problem of vegetation cover[6-8] and soil degradation[9-11]. Rain and river floods were also studied in depth in the Sahelian space, particularly in western Niger[12,13].

In Niger, on lands that are increasingly covered with vegetation, valleys are appearing, some of which are getting bigger from year to year, while in others, temporary or even permanent runoffs are resurfacing. The Diaspora valley located to the west of Niamey, whose water resurfaced in July 2017 (N 13 34.188 and E 2. 01.794) following the heavy rains in June, presents a flow that widens downstream. This has led to a recomposition of the biotope and agro-pastoral practices such as gardening (off-season crops) and fodder crops

such as *Echinocloa stagnina*. This locality, like the entire periphery of the Niger capital, Niamey, is suffering from the consequences of the uncontrolled urban expansion with a destabilization of the peri-urban vegetation. The western part of Niamey rests on the extension of the Liptako-Gourma basement; rainwater and also that from the septic tanks of the new residential districts supply the alluvial groundwater, causing excess humidity and capillary rise. This study seeks to analyse these new features of climate variability in the Sahel.

II. Material and Methods

2.1 Presentation of the studied area

The city of Niamey, covering an area of 500 km² with an estimated population of 2 million inhabitants, is made up of five communes, the first four of which are located on the left bank of the Niger River. Niamey is located in the Sahelian zone with a climate characterized by a long dry season (October to May) and a short rainy season (June to September).

The site is situated in the communal district of Niamey I, situated at the Diapora city crossed by the RN1 (figure 1).

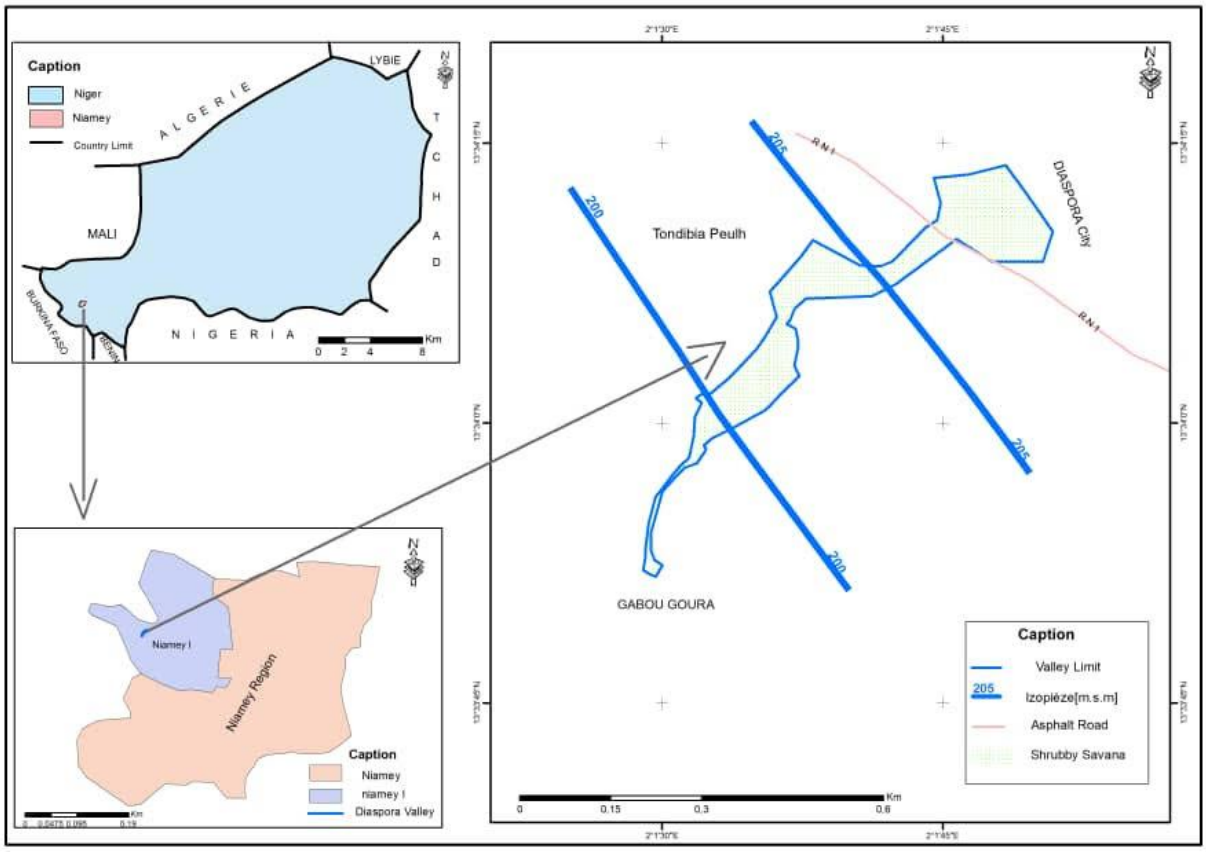


Figure 1: Location of the site (Communal district of Niamey 1)

The vegetation has a steppe tendency and is composed of species such as *Faidherbia albida, Balanites aegyptiaca, Acacia nilotica*.

The geology of the commune is characterized by a plateau that borders the left bank of the Niger River. It is crossed by several koris (Dar Es Salam, Goudel Gorou, Soudouré, etc.) which may have seasonal flows in case of heavy rainfall. Three types of soils can be distinguished here; namely, sandy soils on the plateau which extend over most of the urban area on the left bank. Soils with impermeable shells that outcrop along the cornice and soils with alluvial deposits that occur in the lower bottom of the river valley, consisting of fluvial sand gravel and gravel at the base.

2.2 Data and methods

Rainfall statistics from Agrhymet and the Regional Directorate of Agriculture in Niamey were used to calculate the mean, standard deviation and standardised indices. Geoclim made it possible to distinguish the means of the isohyets in the western region of Niger.

By means of soil and water analyses and floristic inventory, this study analyses these new peculiarities of climatic variability in the Sahel.

The SPI (Standardized Precipitation Index) of 1950 - 2019 was used to detect rainfall variability across wet and dry periods.

2.2.1 Sampling and floristic surveys

In order to conduct the study, the valley was delimited and geo-referenced to a GARMINE GPS. In the delimited area, sampling units (plots) were set up at the start and end of the valley. Within these units, sociological and phyto-sociological surveys were carried out using the Braun-Blanquet method. This method consists of assigning a coefficient of abundance-dominance to each woody species present in the plot.

The Braun-Blanquet scale is as follows:

5 : species covering more than 75% of the surveyed area, i.e. an average coverage (RM) of 87.5%;

4: species covering between 50% and 75% of the surveyed area, i.e. a mean coverage (MR) of 62.5%;

3: species covering between 25% and 50% of the surveyed area, i.e. an RM of 37.5%;

2 : species covering between 5% and 25% of the surveyed area, i.e. a RM of 15%;

1: abundant to scarcely abundant species covering less than 1% of the surveyed area, i.e. a RM of 3%;

+ : rare species and covering less than 5% of the surveyed area, i.e. a RM of 0.5%.

This technique has been used by several authors in the study of tropical vegetation[14-19].

The data collected were entered on Excell 2007. The PCORD 5 software was used for data analysis. In order to assess the data from the inventory, the parameters below were determined.

Specific richness

The species richness (S) of a community or stand is the number of species in that community or stand.

2.2.2 Soil sampling

For this study, samples were taken in the Upstream (bare soil) and Downstream (T. Austalis) of the site at a depth of 0-25 cm, at each point the samples were taken four (4) times at different locations using an Auger. The samples were homogenized to form a composite Upstream and a Downstream sample.

2.3 Methods of analysis of soil samples

The two composite samples collected in the field were analysed at the Quali control laboratory. The parameters selected for evaluation were presented in Table 1.

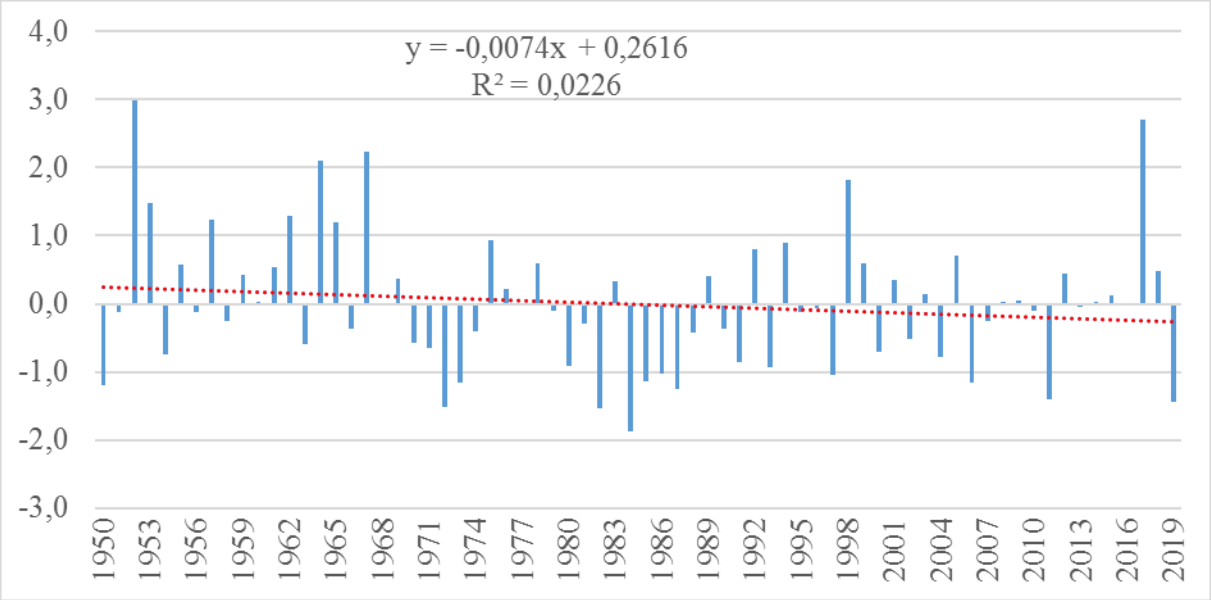
2.4 Water sampling

Water was collected in a vial and stored in a cooler and transported to the laboratory on the same day. The results of the water analysis are recorded in Table 2.

III. Results

3.1 Climatic conditions

To illustrate the climatic variability of the locality, the SPI from 1950 to 2019 was calculated.

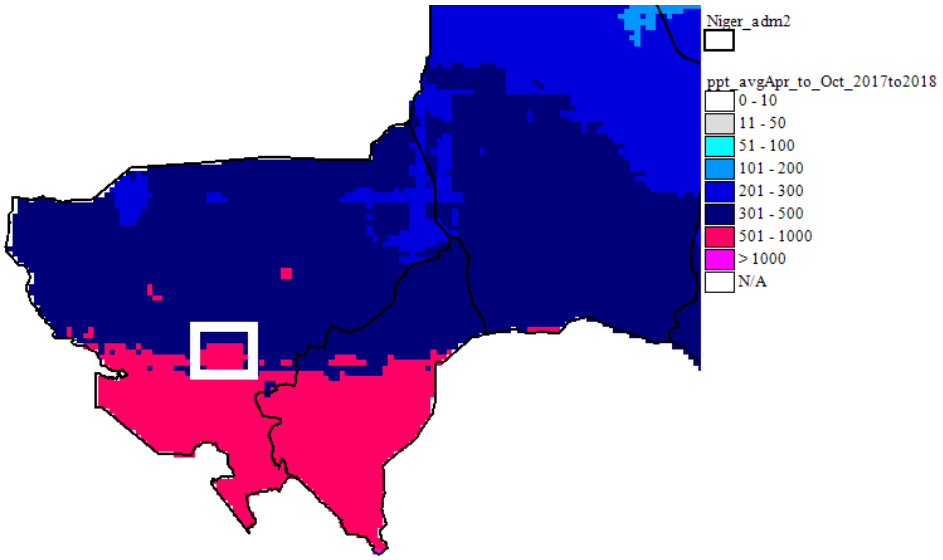


Graph: Standardized Index and Precipitation Trends 1950 - 2019

Source: Statistics of Agrhymet 2019 and of Regional Directorate of Agriculture; Niamey 2020

Although the downward trend and series of deficit years have been observed since 1983, the year 2017 was largely in surplus (27%). It was mainly as a result of the intense localized rainfall of the decade 11.06 - 20.06 2017 having totaled 223.1mm that a small pond formed in the middle of the Diaspora Ravine and which lasted

until October. Just after this pond dried up, the water table has re-surfaced for the first time in November 2017. Since August 2018, the pond has become permanent by expanding downstream.
The average rainfall between 2017 and 2018 around Niamey-Square shows a slight excess, which is evidence of the localized rains announced in the paragraph above.



Map: Mean rainfall 2017-2018 in western Niger
Source: Geoclim Statistics, West-Niger, 2020
At the edge of the run-off area (2 to 11 m wide), the water table is 14 cm.

3.2 Area's ecology

The change of biotope is characterized by the drying up of species that no longer tolerate enough humidity (*Balanites aegyptiaca*, *Accacia Albida*...) and the appearance of hygrophilous species (*Typha australis, Ipomoea asarifolia...).* Having a fast spreading ecology, *Typha australis* is colonizing the whole valley.

3.2.1 Floristic composition

The floristic inventory of the Diaspora Valley has identified twenty-eight (28) species (table 1), divided into eighteen (18) families (table 2), the most important of which are respectively the *Asclepiadaceae*, *Cyperaceae*, *Papilionaceae* and *Poaceae*, each with 10.34%. These families are followed by those of *Euphorbiaceae*, *Cyperaceae* and *Fabaceae* in proportions respectively equal to 6.90%. The remains of the weaker families, each of which represents 3.45%.

Table 1 : List of surveyed species

Species	**Total**
Ipomoea vagans Bak.	1
Pergularia tomentosa L.	1
Acacia nilotica (L.) Willd. ex Del. subsp. Nilotica	1
Andropogon gayanusKunth	1
Annona senegalensis Pers.	1
Azadirachta indica A. Juss.	1
Balanites aegyptiaca (L.) Del.	1
Calotropis procera (Ait.) R. Br.	1
Cenchrus biflorisRoxb.	1
Citrus limon (L)	1
Crotalaria podocarpa DC,	1
Cyperus amabilisVahl.	1

Cyperus reduncusHochst. ex Böck.	1
Cyperus rotundus L.	1
Eragrostis tremulaSteud.	1
Faidherbia albida (Del.) Chev.	1
Hyphahene tebaica (L.) Mart.	1
Indigofera hirsuta L. var. hita	1
Leptadenia hastata (Pers.) Decne.	1
Moringa olifera	1
Penisetum pedicelatum Trin,	1
Phyllanthus pentandrusSchum. et Thonn.	1
Sclerocarya birrea (A. Rich.) Hochst.	1
Sesbania pachycarpa	1
Sida cordifolia L	1
Tephrosia purpurera (L)	1
Thypha australys Schum et thonn	1
Walteria indica(L)	
Total	29

Tabel 2: Soortenfamilies

Families	***Total***	*Frequencies(%)*
Anacardiaceae	1	3,45
Annonaceae	1	3,45
Arecaceae	1	3,45
Asclepiadaceae	3	10,34
Balanitaceae	1	3,45
Convolvulaceae	1	3,45
Cyperaceae	3	10,34
Euphorbiaceae	2	6,90
Fabaceae	2	6,90
Fabaceae-mimosoideae	2	6,90
Fabaceae-papilionaceae	1	3,45
Meliaceae	1	3,45
Moringaceae	1	3,45
Papilionaceae	3	10,34
Poaceae	3	10,34
Rutaceae	1	3,45
Stercullariaceae	1	3,45
Typhaceae	1	3,45
Total	29	100

3.2.2 Description and propagation of Typha australis

Ecology and Systematic Position of *Typha australis* Schum and Thonn

The botanical nomenclature for this plant is still poorly known or uncertain. It is an herbaceous plant that would belong to the phylum of spermaphytes, the sub-splum of angiosperms (*Magnoliophyta*), the class of monocotyledon (*Liliopsida*), the order of typhoid and the family of typhaceae. The species Typha australis is a

large (up to 2 metres high) perennial aquatic plant, which takes root at the bottom or on the edges of stagnant water bodies[20].

Biology of *Typha australis* Schum and Thonn.

It is a plant whose leaves have parallel edges, 1 to 2 cm wide and 1 to 1.5 m long. They have a 1 cm wide blade with a rounded back without edges and very characteristic of the species. The flower spike has a long (15 to 20 cm) reddish cylindrical spike. The flowers are unisexual and very rudimentary. It is intolerant to drought and/or heavy flooding[21].

Geographical distribution. *Typha australis* has a pantropical distribution and is found in both tropical and Mediterranean areas[22].

Development and multiplication of the species

The propagation of the species is by seed dissemination (sexual reproduction) and by rhizome multiplication (vegetative reproduction). At maturity, thousands of seeds are transported by wind (anemochory) and by irrigation water (hydrochory), which, if they find a suitable wetland, will develop. Typha seeds can germinate under almost total anaerobic conditions. This characteristic accelerates the colonisation of the environment to the detriment of other species and thus increases the threat to plant and animal biodiversity.

Survey Ordering

The matrix of twenty-nine (29) plant species identified was subjected to a correspondence factor analysis. The results enabled the identification of three plant groups, G1, G2 and G3, at the 7.16% threshold (Figure 3). Group G1 to *Cyperus rotundus* L. and *Cyperus rotundus* L.; group G2 to *Typha australis Schum and thonn* and group G3 *to Cyperus amabilis Vahl and Eragrostis tremulaSteud*.

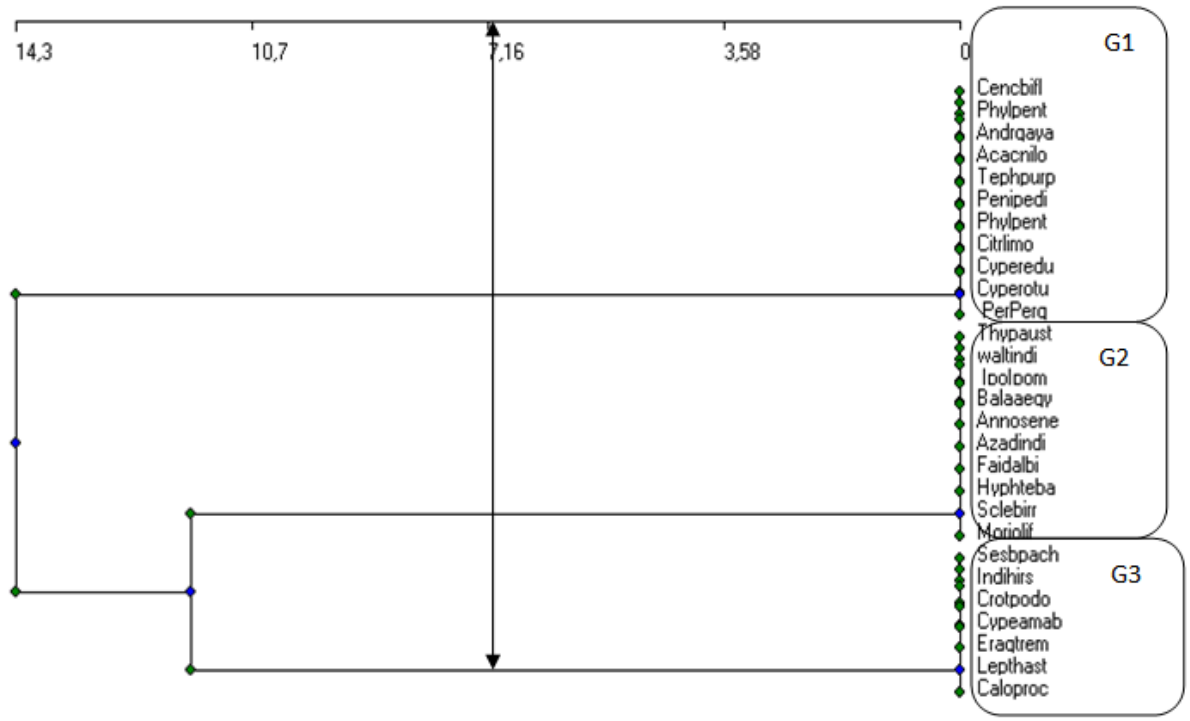


Figure 3: Dendrogram of plant groupings

3.2.3 Soil characteristics

Table 1: Upstream and Downstream Soil Analysis

Table 1: The results of the analyses show a decrease in soil conductivity (57.7 µS/cm), sulphate (8 mg/l), soluble (3.3 mg/l) and extractable (3.5 mg/l) sodium, and an increase in chloride (10,132 mg/l), extractable potassium (8.75 mg/l), calcium (47.6) and nitrate (5,752 mg/l) downstream of the site.

Parameters	Units	Amount	Downstream side
Conductivity	µS/cm	195	57,7
Chloride	mg/l	5168	10132
Sulphate	mg/kg	38	8

soluble Na	mg/kg	5	3,3
Extractible Na	mg/kg	5	3,5
Extractible K	mg/kg	5,75	8,75
Calcium	mg/kg	16	47,6
total N	mg/kg	2913	5752

3.2.4. Water analysis

Analyses of the water at the site show a pH lower than normal (7.1), a high level of bicarbonate 244 mg/l and a low level of calcium 16.2 mg/l compared to normal.

Parametres	Results	Units	Norms
pH	7,1	-	8-5
Conductivity	280	µs/cm	<700
Bicarbonates	244	mg/l	<150
Chloride	10,01	mg/l	<140
Sulphates	45	mg/l	34-240
Sodium	8,33	mg/l	0-30
Potassium	0,59	mg/l	0.5-5
Total iron	0,67	mg/l	0.2-1.5
Calcium	16,2	mg/l	40-120
Magnesium	9,24	mg/l	6-25
Nitrates	10,9	mg/l	50
Ammonium	0,08	mg/l	-
RAS	0,4	-	<3

IV. Discussion

Climate change and its impact on water resources lead to a disruption of seasonal rainfall[23]. Of course, the Sahel continues to suffer from consequences such as increased gullying[9] or desertification, but new phenomena should not remain unstudied.

The case of the diaspora valley is a perfect illustration of this with the waters that resurfaced in 2017 following a flood. This situation has favoured the proliferation of T.Australis, an invasive plant. Indeed, the presence of this plant has led to the modification of the physico-chemical properties of the soil. The analysis of the water quality gives a pH equal to 7.1 higher than the pH of an analysis of the river water in Tondibia near the valley with an average of 6.8[24]. Bicarbonate ions can be derived from the weathering of certain minerals such as calcium carbonate[25] and bicarbonate concentrations in groundwater generally range from 8 mg/L to 43 mg/L[26]. Based on the pH value (7.1), the high bicarbonate rate (244 mg/L) and the low calcium rate (12.2 mg/L), T.Australis had an effect on water quality by altering the calcium and causing the high bicarbonate rate and pH and confirms the results of Abderrahmane Boudoukha et al, 2012[27].

The two soil samples (Upstream and Downstream) have different physicochemical parameters. In this ecosystem, the presence of T. australis favours an increase in the concentration of certain chemical elements in the soil, notably chloride (10 132 mg/l), calcium (47.6 mg/l) and nitrate (5 752 mg/l). This situation is detrimental to the development of certain local species present in the ecosystem downstream of the site, notably *Faidherbia albida* and *Balanites aegyptiaca*, for which there is a high mortality rate in the environment.

Typha australis is an invasive plant in aquatic environments with a very rapid mode of propagation. The diaspora valley is linked to the hydrological basin of the Niger River. In this ecosystem, activities such as rice cultivation, off-season crops and several other activities are practiced. The diversity of the activities practiced by the local populations testifies to the strong potentialities of the valley basin. The results on the analysis of water samples show the very high presence of chloride. This constitutes a favourable environment for the development of the plant. These results are similar to those of Bagani Gbr(2001)[22] which found salinity values ranging between 0 and 1.6% in the Senegal River delta. In the diaspora valley, the proliferation of the plant is stifling the development of herbaceous and woody flora, of which more and more dead feet of *Faidherbia albida* and *Balanites aegyptiaca* are recorded, and the disappearance of *Echinochloa stagnima* (Bourgou) in the river bed is a growing concern. Through a study carried out by the Integrated Management of

Proliferating Aquatic Plants in Niger (PGIPAP) project, which involved 24 pools totalling 2266 ha, *Typha australis* invaded 1534 ha (Table 1), i.e. an average infection rate of 70.7%.[28].

District (name)	Department (name)	Pond (name)	Surface (ha)	Surface Infested (ha)	Infestation rate (%)
ZINDER	Mirriah	Guidimouni	90	60	67
		Lassouri	150	60	40
		Gouchinchin	40	27	67
		Baban Roua	30	27	90
	Magaria	Gocholo	30	20	67
		Maigatari	20	12	60
		Wiwi	85	57	67
		Mai Yan Mata	25	20	80
	Kanché	Pampami	30	24	80
TAHOUA	Birni N'Konni	Dosseye	200	180	90
		Rouafi	80	48	60
		Toumboula	60	40	67
Dosso	Boboye	Douloubé	50	40	80
		Doubangou	16	14	90
		Garou	50	35	70
		Moumbéna	45	36	80
		Tadé	150	101	67
		Niebéré	100	75	75
		Djambe			
	Gaya	Malgorou	100	75	60
		Wadata	100	60	60
		Tella	350	210	60
		Barba	400	280	70
		Balé	10	6	60
		Bangoubi	30	27	90
Total			**2266**	**1534**	

Source (CNEDD, 2010)[28].

The results of this report show what is at stake in the threat of *Typha australis* in Niger's aquatic ecosystems. The data from this study contribute to the knowledge of this invasive plant and the stakes to which the banks of the Niger River are exposed through the dissemination of its seeds by zoochorie(animals) and anemochorie(wind). The diaspora valley must be protected from biological or mechanical means of control to avoid the proliferation of the species.

Threat

The proliferation of Typha in the environment has several consequences

- On the environmental front

By its rate of spread, *Typha australis* suffocates other local species of socio-economic importance to people and animals. In the Diaspora Valley there are more than six feet of dead *Faidherbia albida*, about ten feet of suffocated *Balanites aegyptiaca* etc.

- On the sanitary level.

The settlement of *Typha australis* constitutes a biotope particularly favourable to the development of vectors of certain diseases such as bilharziasis and malaria.

V. Conclusion

Through this study, the resurgence of water in the Diaspora Valley illustrates new approaches to climate variability and consequences that differ from those well-known and widely studied in the Sahelian environment. It is not in fact desertification and drought, but re-greening all around the once steppe valley and a phyto-botanical modification.

The results of the present study have enabled us to understand the dynamics of *Thypha australis* through the analysis of the physicochemical elements of its biotope. The kinetics of its proliferation in the environment requires emergency measures to protect the river basins located downstream of the diaspora valley in which the plant's proliferation began. Biological or mechanical control actions must be oriented in the fight against this species. Studies must also be conducted to better understand the biology of this species.

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