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SPATIOTEMPORAL VARIATIONS OF THE HYDRODYNAMIC PARAMETERS OF NDJILI RIVER TO DJAMBALA

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ABSTRACT

The essential goal of this study is to provide information on the variation of the hydrodynamic parameters of the river N'djili which constitutes a source of supply raw water at the company in head of water in the town of Djambala, in order to make it possible to the public and private decision makers not only to become aware on the impacts which these variations with long can pose but also to take measures for the improvement of drinking water production in Djambala, considering its population believes exponentially; then, for the durable management of this river N'djili which is seen threatened of drying up.We noted that the flow and the depth of the N'djili River are proportional to pluviometry. Moreover varies with its depth.This river is the source provisioning of raw water of the National Company of Distribution of water (SNDE).This study made it possible to note some variations of the hydrodynamic parameters of this river which is seen threatening of disappearance by the climatic changes.While appearing with others rivers tekes which made object former studies of the researchers like Olivry J.C (1967), one notices that the depth of the N'djili River is very low.

Keywords: hydrodynamics, batekés, climatic changes, water, djambala, N'djili River, parameters.

INTRODUCTION

Djambala, locality of the Batékés plates and place head of the Department of the Plates were always confronted with the problem of provisioning of water since strong a long time.

Located at approximately 400 km in the north of Brazzaville, Djambala is fed by only one river (N'djili), being to 4 km of its south-east.

The problem of water in the Batékés plates in general and in Djambala in particular was already the object of several former studies of the researchers like [1, 2, 4, 10]

Thus [2] in its title written in 1992, "the Batékés Plates: Water tower congolais or deserted congolais? Declare that:"*water,* even for human consumption is a thorny problem on the whole of the Tékés Plates.The worship of water on these plates is very enracine in the traditions of the Téké populations which live there.The invocations of the rain at the time of the drynesses are not rare there.Moreover the idea according to which Tékés has the control and the capacity to make fall the rain is very repende in Congo".

In front of the drinking water problem which arises with acuity in Under Prefecture of Djambala on the one hand and the growth of the population on the other hand, the study of the variations of the hydrodynamic parameters (Width, depth and flow) of the river N'djili does not prove of importance capital. The Batékés Plates which extend to North from Brazzaville between the Southern second and parallel fourth, are the remainders of a structural surface covering a surface of 38400km^2, very slightly tilted towards the North-East (basin congolese). Located at 700 or 800 m of altitude, they dominate of 300 m the valleys which border them and distinguish them in four distinct units [3]:

- The Plate of Mbé or Batéké Plate ranging between the Congo River and Léfini of a surface of approximately 7.500km^2;
- The Plate of NSA enters Léfini and it kéni covering approximately 4.000 km^2;
- The Plate koukouya between Mpama and Lékiti covering approximately 410 km^2;
- The Plate of Djambala enters Mpama and it kéni.

The surface of each one of them slightly inclines west towards the Est [4].is bordered in the West, North and the South by high hills whose tops are with sorrows less low than the Plates.

The vegetable cover is formed in major part of a more or less shrubby savanna in the medium of which some forest solid masses and of the thickets are scattered which continue to the river N'djili [3].

In this savanna, several dry valleys are also converging towards the river N'djili.

THE STUDY AREA

The valley of N'djili is not bordered of the beginning to the end by a forest gallery. At the bottom of this valley, are very white sands that [4] compares to sands constituting the terraces of Lékéti.[4] would have also found these sands on the first terrace which overhangs Congo of a few meters.They are white sands "of snow" that [5] described.

From the hydrological point of view, the river N'djili is not the most significant river and nearest to the

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town of Djambala. The sandy formations that notch N'djili are not silicify has intersected stratifications.

N'djili is not thrown in Mfourga which in its turn is thrown in Léfini, an affluent of the Congo River.This N'djiliRiver being the subject of our study has a laminar flow and takes its source with Inaou [6].

Our experimental site is located downstream from this source more precisely at the following geographical co-ordinates: S:02 34' 19,2' ' and E:014 47' 14,5' ', altitude 451 Mr. This point is located upstream at a few meters of the site where the National company of water distribution (SNDE) of Djambala supply out of raw water.

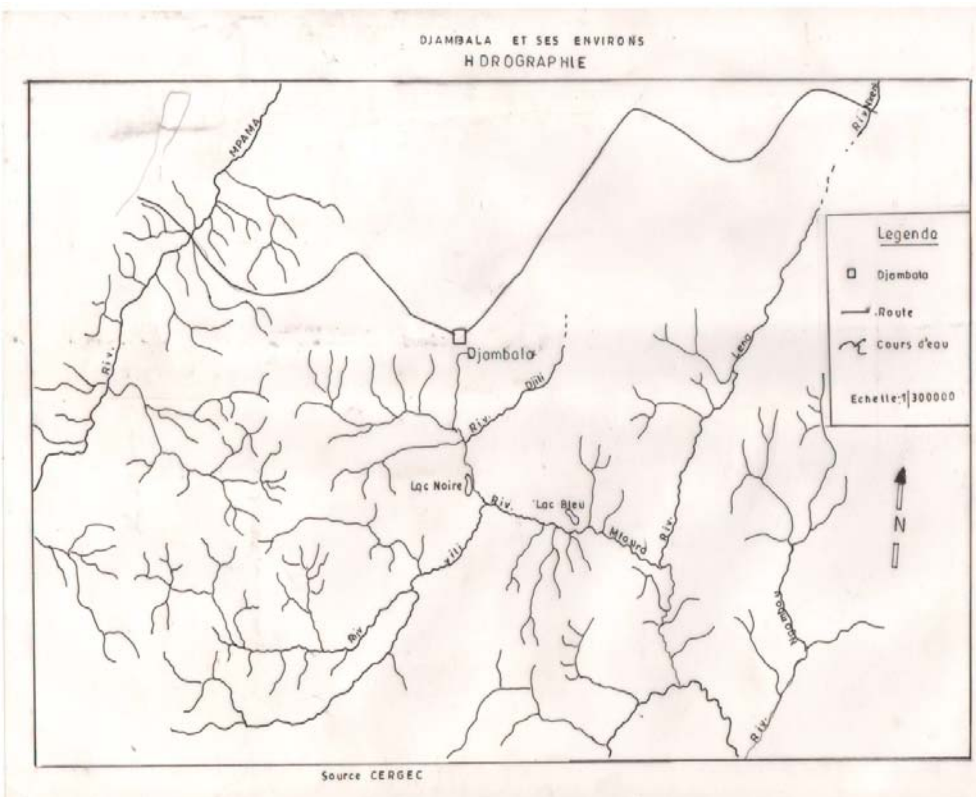

Figure-1. Hydrographic chart of Djambala and its surroundings (Study area) [7].

Point of considering climate, like all the department of the plates, it is of subequatorial type guinéen [8]and is characterized by:

- Precipitations going of 1600 to 2100 mm;
- An annual average temperature ranging between 23°C and 25°C;
- An annual thermal amplitude of 1.5c and;
- One season dries of which the duration lies between 2 and 4 months and who is characterized by a monthly average temperature higher than 18c for every month of the year.

The insolation is not very significant with less than 1700 hours of insolation per annum as us indicates it [4] On the other hand, the moisture content is very high since it borders the 80% with weak monthly variations of about 10% and of the amplitudes high day labourers.

The great dry season generally begins in June to be completed in September; one observes a bending of pluviometry in January and February like the indice the following figure:

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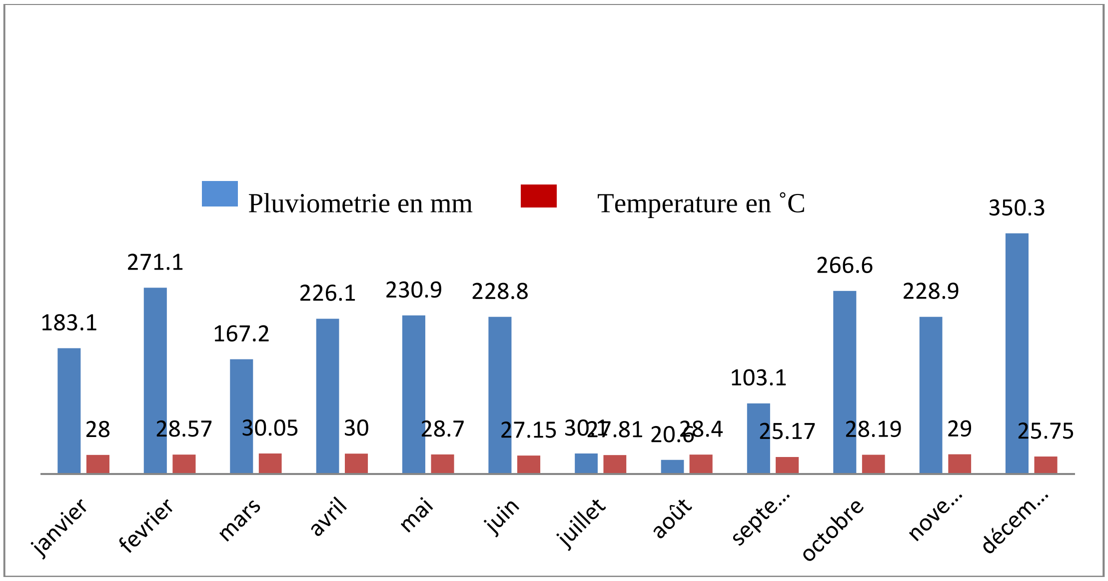

Figure-2. Average variation of pluviometry and the annual temperatures with Djambala (Source: ANAC Djambala, 2012).

The vegetation as for it is a function of the ground, altitude and the slope.The shrubby layer of savannas is dominated by hymenocardiaacida, *Annonaarenariasenegalensis*, *Ochnagilletii*, *Syzygiumguineense*, *Bridelia-ferruginea*, *Vitexspp*and the herbaceous layer by *maximum Loudetia spp. Panicum.Landolphia spp. Trachypogonthollonii, Cteniumnewtonii, Hypparrhenia will diplendra*[9].

The forest with *Parinariexcelsa*constitutes the climatic forest stage of the Batékésplates.Its degradation would lead to the appearance of forest with *Dialiumpolyanthum*then to *Milletialaurentii*and *Piptademiastrumafricanum*.The degradation of this climatic forest is accompanied by a reduction in the organic quantity of matter on the surface of the ground, which is at the origin of the brittleness of the ecosystem of the Batéké Plates.

One also distinguishes from the colonizing riparian forests with *Alchorneacordifolia*or *Ancistrophyllumsecundiflorum*, of the riparian forests with *Uapacaheudelotii*and *Irvingiaspp*, marshy forests with *Mytragynaaleastipulosa*, raphiales and easily flooded forests with *Eristomadelphusexsul*[8].

The geomorphology of this area is that of a structural plate in the process of dismantling. The broad outline is simple, but one meets interesting forms of detail. The current forms are typical for each type of ochre ground, sands and sandstone.

Current erosion is especially the fact of precipitations. The rains are significant so much in quantity than in intensity and their mechanical action on the ground is supported by the weak protection of the vegetable cover regularly destroyed by the bush fires.

With regard to the shapes of the batékés plates, the highest part of the Plate of Djambala is dissected by a network rather dense and quite arranged hierarchically of dry valleys. They gather very to form the valley of N'djili.

The large rivers which separate the plates, Léfini, Lékéti, Mpama, run in broad valleys flat-bottomed. The beds very sinuous and are bordered by the typical forests galleries [10, 11]

The Batékés Plates correspond to structural surfaces pleistocenes; their altitude varies from 890 m on the Koukouya Plate to 600 m on the Plate of Mbé in edge of the Congo River. The monotony of these tabular surfaces is stopped by dry valleys with the forms sharp (Guillot, B and Peyrot, B, 1979) and by depressions closed on the edges pseudo-dolines * or podzols * [12].

The plates are separated by valleys steep sided from 300 to 400 m, at the marshy bottom, where the affluents of the Congo River and Alima run. With the periphery of these plates a zone of high hills is, at the tops rounded, separated by dry valleys.

The series of the Batékés Plates is subdivided in two sets, the in-depth polymorphic sandstones and sandy sands ochre or silts constituting the roadbases.

The layer of the polymorphic sandstones, of which the thickness varies from 50 to 300 m, includes/understands tender sandstones with grain ends and regular. Towards the top of this layer appear in bench lenticular discontinuous of the levels silicified and quartzitic of varied colors [4].The shining character and rounded grains of quartz is the consequence of façonnement watery which led to the polishing of the older marks of the wind shocks. They would be thus the

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consequence of a lake resumption of the polymorphic sandstones [8].

With regard to the polymorphic sandstones, [4] distinguishes them by describing them. He distinguishes from top to bottom the following horizons:

- tender sandstones of white color giving by disintegration of white sands;
- silicified hard sandstones, quartzitic of clear, white, brown colour or dew being able to pass laterally to various silicified rocks:sandy chalcedonies, chalcedonies, sandstone with calcédonieux nodules with many small quartz géodes.It is the variety of aspect of these rocks which was worth the qualification of polymorphic to them;
- yellowish and gray white sandstone tender by deterioration and red sandstones.This level with a few tens of meters thicknesses.

All the sandstones present at the outcrop an intersected stratification, granulometry is rather variable.

The levels of the not silicified sandstones are very friable. There are practically no cements, simply a secondary silica film around the points of contact of the grains and a little kaolinite.Sometimes cement is ferruginous.

The sandstones being of wind origin, the intersected stratifications probably correspond to old formations dunaires which one can try to find the general orientation.

With the top, one distinguishes the series from the Batékés Plates, subdivided in an erotogenic polymorphic sandstone level, and in a Neocene higher coat argilo-sandy "the total power of these two formations is approximately 420 m", [4]. The series of the Stanley-Pool would have of about fifty meters of power, that of the erotogenic polymorphic sandstones, 280 m, and covering argilo-sandy, of 90 m.

The sandstones of the Stanley-Pool begin with mudstones, then have a compact level and end in tender white arkose, in which one very clearly observes stratification intersected of wind origin.

The grounds of the Batékés plates were largely described by [3], of which one of research was directed towards "the grounds of savanna of the Batéké plates".

The grounds of this department are grounds ferralitic washed out of iron and clay, formed on a material sablo-faiblement argillaceous, low in base and of high permeability [3].The most remarkable characteristics of these grounds are dependent on the organic type of matter and its distribution in the profile. The major humus-bearing penetration is possible because of the movable and permeable character of original material.

MATERIALS AND METHODS

To undertake this research task, several materials were used on the ground, namely:

A double decameter, a stop watch, a GPS, a stop watch, a ladder liquid level recorder, an artificial float, a hammer, markers, machetes, hammers, computers and software adapted, brushes, a numerical camera, and others.

The methodology used for the realization of this study is the gauging with the float, in particular the method of the ballasted floats. The float used is a plastic bottle

We will quote the method of the floats ballasted for memory because it is used enough. Its application can be made only in sections perfectly gauged in-depth over a certain length. It gives good results in the case of speeds very weak where the use of the winch is not possible any more as in our case.

For the installation of our device, we chose a rectilinear space over a length of 15.30 Mr. This lengths remained invariable until the end of our study. [13]

Then, we carried out marks on some trees being at the ends of this space.

It is on this arranged surface that we took our measurements for the study of the variation of the hydrodynamic parameters of the river N'djili.

Measurements of widths, depths, and flow carried out weekly during all the duration of our study.

RESULTS AND DISCUSSIONS

The various measured and/or calculated parameters are:

Average surface: Average surface is the product length and the width of a given section. Being given that our delimited space is rectangular, we go represented by a rectangle ABCD (see Figure-1). The sections AB and CD are rigorously parallel and accessible in rising; their values vary. Thus, the distance AC = data base = L = 15,30 m (invariable length) and outdistances it AB = CD = L (width).The arrow indicates the way of the float.

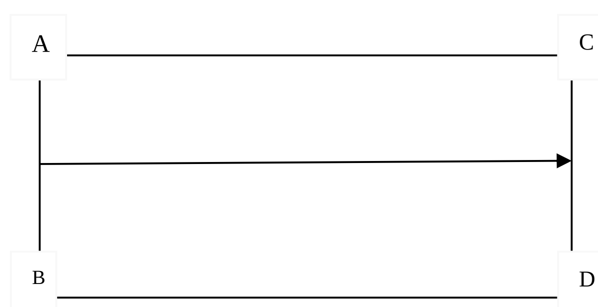

Figure-3. Diagram of the experimental site.

Surface (S) of has right-angled (ABCD) is the product length by the width. One deduces some:

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$$S_m (m^2) = L (m) \times l (m)$$

S_m, average surface;
L, the length of delimited space (L = 15,30m) and;
L, la largeur moyenne A.N : S_{m1} = 15,30 m × 8,36 m = 127,91m².

Average speed:according to [13], if V is the presumably constant speed of the float between the two sections AB and CD, we have:V_{ms}, mean velocity of surface;
L, the length of delimited space (L = 15,30 m) and;
T, average time for the float to traverse the distance L.

$$V_{ms} (m/s) = L(m)/t (s)$$

We measured this time with a stop watch. Thus, an operator places himself in the section CD with the stop watch, another in section AB with the float. The operator being in section AB will release the float with the signal of that being in the other section with the started stop watch. As soon as the float arrives in the section where CD is, the operator stops the stop watch and notes time.

All the results mean velocity of each month appear in the table hereafter:

Table-1. Monthly mean velocity of the N'djiliriver.

Months	**Average speed of flow V_{ms}**(m/s)
August	$V_{ms(1)}$ = 15.30m/25.11s = O.61m/s
	$V_{ms(2)}$ = 15.30m/25.32s = 0.60m/s
September	$V_{ms(1)}$ = 15.30/26.05 = 0.59m/s
	$V_{ms(2)}$ = 15.30/27.81 = 0.55m/s
	$V_{ms(3)}$ = 15.30/27.91 = 0.54m/s
	$V_{ms(4)}$ = 15.30/24.99 = 0.6122m/s $V_{ms(5)}$ = 15.30/24.98 = 0.6125m/s
October	$V_{ms(1)}$ = 15.30m/24.89s = 0.61m/s;
	$V_{ms(2)}$ = 15.30m/22.98s = 0.67m/s
	$V_{ms(3)}$ = 15.30m/23.50s = 0.65m/s
	$V_{ms(4)}$ = 15.30m/24.45s = 0.63m/s
November	$V_{ms(1)}$ = 15.30m/23.44s = 0.65m/s
	$V_{ms(2)}$ = 15.30m/25.47s = 0.60m/s
December	V_{ms}= 15.30m/23.95s = 0.63m/s

Medium flow: According to the theory of gaugings to the floats, the flow Q of a river is equal to the product of average surface (Sm) by the mean velocity of the flow in this section V:

$$Q (m^3) = S_m (m^2) \times V (m/s)$$

S_m is calculated starting from the length and of the width of delimited space.

V, the rate of flow is estimated starting from the mean velocities of surface. Thus, the mean velocity of flow of a river accounts for 80% is 0,8 the mean velocity of surface [13].

By what precedes, one deduces some:
V (m/s) = 0,8 ×Vms.Then, the formula of the flow is written finally in the following way:

$$Q (m^3/s) = S_m (m^2) \times 0.8V_{ms} (m/s)$$

Q_1 = 124,69 m² × 0,8 × 0,61m/s = 61m³/s (It is in this way that all the values of the flows were calculated).

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Table-2. Summary of the averages of the various parameters measured and calculated.

Dates	Average width (m)	Depth(m)	Average area (m^2)	Average speed of flow (m/s)	Average debit (flow) (m^3/s)
19/08/2012	8.15	1.06	124.69	0.61	61
26/08/2012	8.20	1.06	125.46	0.60	60.22
02/09/2012	8.19	1.06	125.31	0.59	59.15
10/09/2012	8.07	1.06	123.47	0.55	54.33
16/09/2012	8	1.07	123.40	0.55	54.30
24/09/2012	8.45	1.09	129.29	0.61	63.09
30/09/2012	8.25	1.10	126.23	0.61	61.60
07/10/2012	8.50	1.13	130.05	0.63	65.54
14/10/2012	9.21	1.17	140.91	0.67	75.53
20/10/2012	8.88	1.22	135.86	0.65	70.65
27/10/2012	8.19	1.25	125.31	0.62	62.15
03/11/2012	9.29	1.08	142.14	0.65	73.91
09/11/2012	8.16	1.09	124.85	0.60	59.93
29/12/2012	9.38	1.16	143.51	0.66	94.72

RELATION BETWEEN THE VARIOUS HYDRODYNAMIC PARAMETERS

Flow –Pluviometry

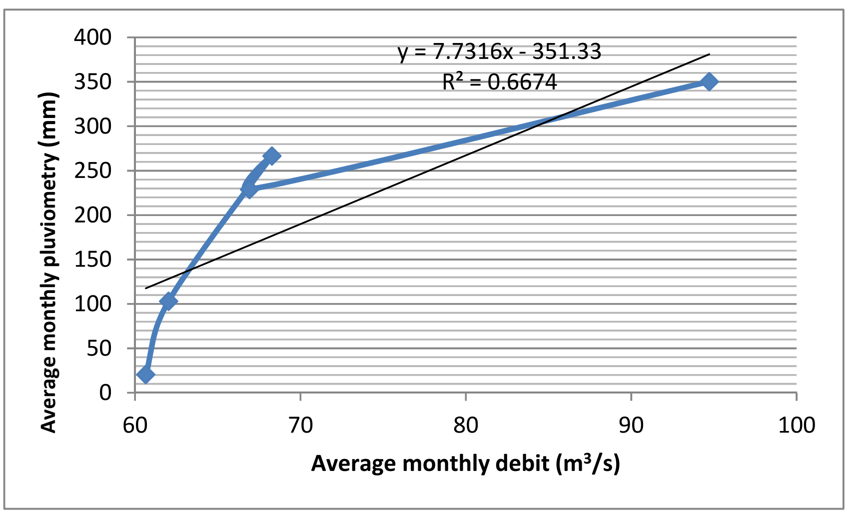

Figure-4. Variation of the flow according to pluviometry.

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Depth - Pluviometry

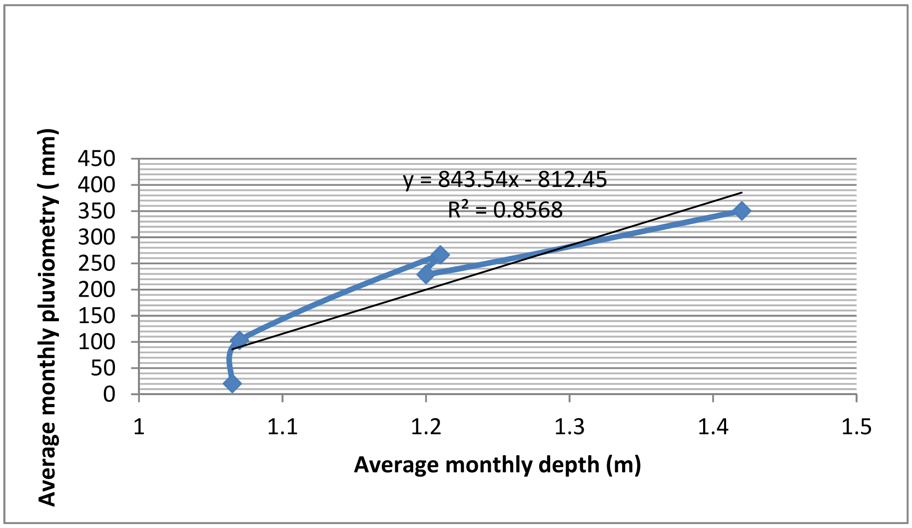

Figure-5. Variation depth according to pluviometry.

Flow - Depth

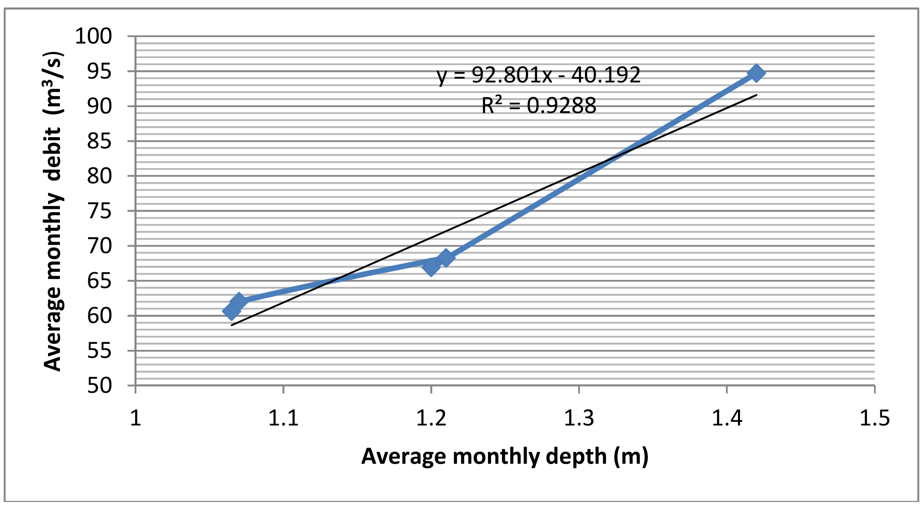

Figure-5. Variation of the flow according to the depth.

The various values of the flows calculated during the period of our study shows that the flow is proportional to pluviometry. This evolution of the discharge of river N'djili is not marked of course by the increase in the quantity of rain fallen into the locality from Djambala during this period.

Concerning the curve depth-pluviometry, these two parameters go in perfect evolution according to their values. Thus, the depth of the river N'djili is not proportional to the quantity of the rain fallen into the zone. The curve expressing the variation of the flow compared to the depth is the result of the gaugings carried out during all the period of our study. The values depth was measured directly on the ground while those of the flow were calculated.

Even light reduction depth and flow noted in explain November by the decline in the quantity of rain fallen to the current this month.

According to the results obtained, we confirm that the river N'djili is not one of the regular rivers of Djambala. The variation of the monthly flows testifies this regularity still better. Thus, the values of the monthly medium flows are always higher than 60 m^3/s during every season of the year.

However, we noticed that the depth of the river N'djili very weak compared to the other rivers is tékés

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which one is already the subject of the former studies. Because the measured values of this parameter never reached 2m;they lie between 1 and 2m.

We compare here our results with those of [10].The monthly average width evolves/moves in a linear way.

The linearity of the width of the river N'djili does not relate to the quantity of rain fallen into the locality from Djambala.

The variations of the flow, depth and width of the river N'djili do not depend on the quantity of rain. The monthly values of these parameters testify this dependence well.

The more the quantity of rain increases in the locality of Djambala, the more the values of these parameters increase. The reverse is observed with the bending of this quantity of rain in November.

The influence of the variations of the hydrodynamic parameters of the river N'djili on the production of drinking water with Djambala was not really noted during our study. However, we predict that the variations of the flows can entrainer a drying up of the river N'djili, because the drying up of a river depends on its physical characteristics, i.e. the permeability, porosity etc. Indeed, the comparative study of the drying up of the rivers batékés carried out by [10] on the Batékés Plates showed that this one is justified thanks to the homogeneity of the grounds and with the constancy of the physical characteristics of one basin to the constancy of the physical characteristics from one basin to another.

The drying up of the river N'djili is not only one question of month or one year but foreseeable because the low weekly flows express it well.

The pumping of the water of the river N'djili by the SNDE with a flow of $45m^3/S$ is carried out without a checking of the variations of the hydrodynamic parameters of this river since the creation of this factory until our days, for lack of materials. Indeed, this negligence does not contribute such step to the drying up of this river without wanting it?

The simple reading of the weekly flows carried out on N'djili during the dry season of 2012 shows that drying up is very slow. However, one realized that the variation of the monthly flows expresses better drying up that the weekly flows.

In spite of the multiple sources and rivers met in the surroundings of the town of Djambala, the problem of water still arises in this city. Considering the high altitude of Djambala, no well or drilling was installed in Djambala until now. The population of this city consumes only the water of the National Company of Distribution of Water which is not regular.

CONCLUSIONS

Considering its altitude and its large surface, no direct observation by drillings was carried out in this city. The population of Djambala is often useful itself of rainwater, of some rivers and surrounding sources of the city.

The public company in load of water is supplied out of raw water of the river N'djili, this study allowed to note some variations of the hydrodynamic parameters of this river which is seen threatening of disappearance by the climatic changes.

During my study, several variations were observed: variations of the width, the depth, as well as flows and precipitations. Among these variations, more influencing are those of precipitations and the flows. To this end, the variations of noted precipitations really influenced the flows, these depths and the widths monthly magazines of the river all the time lasting N'djili of our study.

The results of our study will allow the public and private decision makers in load of the question of water of taking measures adequate so that the N'djili river continues to meet the needs for the populations.

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