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Reserves Evaluation of Kisanga II aquifer at Lubumbashi (DR Congo)

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ABSTRACT: Nowadays, the management of water capital becomes an alarming situation, worrying the authorities of many countries. The purpose of this study is to assess the capacity of the Kisanga II aquifer in order to serve the population of the city of Lubumbashi with water of sufficient quality and quantity in order to reduce the shortage of water. Hydrological observations were made over a period from 2014 to 2015. They reveal the behavior of the aquifer during the critical periods (dry season, dry episodes). From these observations, the authors describe the morphological and morphometric characteristics of the catchment drained by the river KISANGA II; evaluate the reserves of the aquifer of the basin, using the flood hydrograph raised by them; Then they discuss the significance of these results obtained by applying the empirical formulas of MAILLET & WERNER, TISON & DUNSQUIT and then explain the index of storage and the rate of renewal; establishing the optimum conditions for the use of this aquifer in case of abusive exploitation and finally providing advice to the managers.

KEYWORDS: aquifer, hydrological observation, morphological and morphometric characteristics, basin, flood hydrograph.

1 INTRODUCTION

The importance of surface and groundwater for the Katanga province and the entire country is well established. Let us recall some use sectors: food, recreators activities, industrial needs, agriculture, livestock... And most water uses materialized by requirements of the order of magnitude; of sufficient quantity and quality. [1]

Population growth is currently very high in the city of Lubumbashi requires more water to cover various needs. Given this situation, it is very important to increase the pumping stations. Apart from this practical reason seems to be an interesting workaround, other scientific reasons can be advanced: first, the flow rates of rivers during the dry period reflect a good regulatory capacity [2] of the aquifer and the other one tries to compare the results given by the two empirical formulas of MAILLET and that of TISON, WERNER and DUNSQUIT [3]

For this study, we used the depletion curve established in 2014 by TSHIBANG, NSENGA and MATETE. Different was determined reserves calculated by empirical formulas (op.cit.) And compare the differences between the corresponding reserves that they give.

In conclusion, having given parameters such as the turnover rate, the reserve replacement period, the index of emmagasinement, we recommend the optimal operating conditions of the web. 1.

1.1 MATERIALS AND METHODS

The gauging station was located just upstream of the confluence with the Kimilolo, fearing that the waters of the latter influence the measurements. The measurements were made possible a rope stretched from one end to the other along the width of the river, on which were carried nodes of 30 apeat from these nodes, the depth was sampled at each point. The flow of the river was calculated with the aid of Reel OTT N°34/91907.

The flow rates of curves were regularly established and controlled by more or less four samples a mouth and from 17 May 2014 to 14 November 2015. In each case the rates was calculated from the data obtained.

Planimeter of the same mark as Reel which permitted us to evaluate the total surface of watershed and this of wet area Kisanga II. Curvometer was used to determine the watershed perimeter

During our investigations two methods were used:

- Gauging method: it allowed us to make several measures reflecting the change in the river flow and its repercussions on the time to be established as the depletion curve from the flood hydrograph;
- Rule of thumb: it facilitated the calculation of reserves of groundwater catchment by MAILLET formulas and WERNER, TISON, DUNSQUIT. To compare the values found. If they are significant, what kind of land does one apply them?

1.2 GEOGRAPHIC SITUATION

The Kisanga II basin covers an area of 13 km^2 in the SW part to about 10 Km from the city of Lubumbashi, to within 800 m of the Kipushi road around Kilimansimba between latitudes 11°43’25” and 11°43’34”South and longitude 27°24’03” to 27°23’57” East. Average high of 122 m.

Fig. 1. Localization Watershed Kisanga II

It is drained by the river Kisanga II tributary of the right bank of Kisanga, fed by three sources of heads adapted for the use of farmers. This basin, part of the great basin of the Kafubu, is formed by sedimentary rocks belonging to Katanguien. These shale formations are sometimes subdivided into series Nguba, Kundelungu and Roan. They have a mixed conglomerate (conglomerate) whose power increases from South to North.

The vegetation observed on the watershed of degraded woodland types. The increase in deforestation over time, repeated brush fires hamper the development of the latter, which directly has the impact on the aquifer. However, the survey revealed phytosociological associations (cash) as follows:

Microphanérophyte (tree and shrub)
Climbing Phanérophyte: creeper (Asteraceae)
Hydrophytes (aquatic prairie, phragmites).

The climate characteristic of the sector is tropical dry, ranked in the type of CW_6 KÖPPEN, two alternating seasons in temperate continental characters linked to altitude and remoteness from oceanic masses. The rainy season runs from November to March (average temperature: 20 ° C) the months of April, May, September, October are so-called transition. The months of June, July and August are buckets. (Average temperature: 14 ° C).

The demonstration of the constituent soil horizons of the profile of the city of Lubumbashi and its surroundings [4] has uncovered soil types of Kisanga II basin. We soils: waterlogged yellow, red, lateritic, black brown (in the lower part: the bed of the water).

2 RESULTS

2.1 SIZE AND SCOPE

The Watershed Kisanga II covers an area of 13 km^2 with a perimeter of 15 km; it is drained by the River II Kisanga fueled by three sources of heads located respectively:

11°43'34,5" S	11°43'31,8" S	11° 43'32,2" S
27°23'54,1"E	27°35'36,5"	E 27° 23'53,7"E
1224 m	1228 m	1223 m

2.2 COMPACTNESS INDEX GRAVELIUS

This is a geometric parameter that provides insight into the general shape of the basin. It is the ratio between the perimeter P of the basin and the perimeter P of a circle having the same area A. it is known that the latter is the minimum perimeter of a given area, so that the maximum compactness index 1. It is expressed as: $P = Kc / 2\sqrt{\pi A} = 0{,}28P / \sqrt{A}$

For Kisanga II, Kc = 0.84: this means that the pool has a compact shape and is short. Flooding at the outlet does not manifest at all next to the late timing of precipitation and will tend to be progressive because of the swamp.

2.3 EQUIVALENT RECTANGLE

It is a rectangle that has the same scope and same surface at the watershed. Knowledge of its length L and width l, explains the concept of compactness Kc index. Its dimensions are calculated from two equations:

$P = 2 (L + l) = 2Kc\sqrt{\pi A}$ and $L \times l = A$

$L = Kc\sqrt{A} / 1.12 [1 + \sqrt{1- (1.12 / Kc)^2}]$

$l = Kc\sqrt{A} / 1.12 [1-\sqrt{1- (1.12 / Kc)^2}]$

The values found are:

L = 4.48 km

l = 2.89 Km.

Given the Kc value <1 the ratio L / l confirms the compactness of the watershed.

2.4 Hypsometric Distribution And Altimeter

Frequency repartition of altimeter and hypsometer Kisanga II that watch

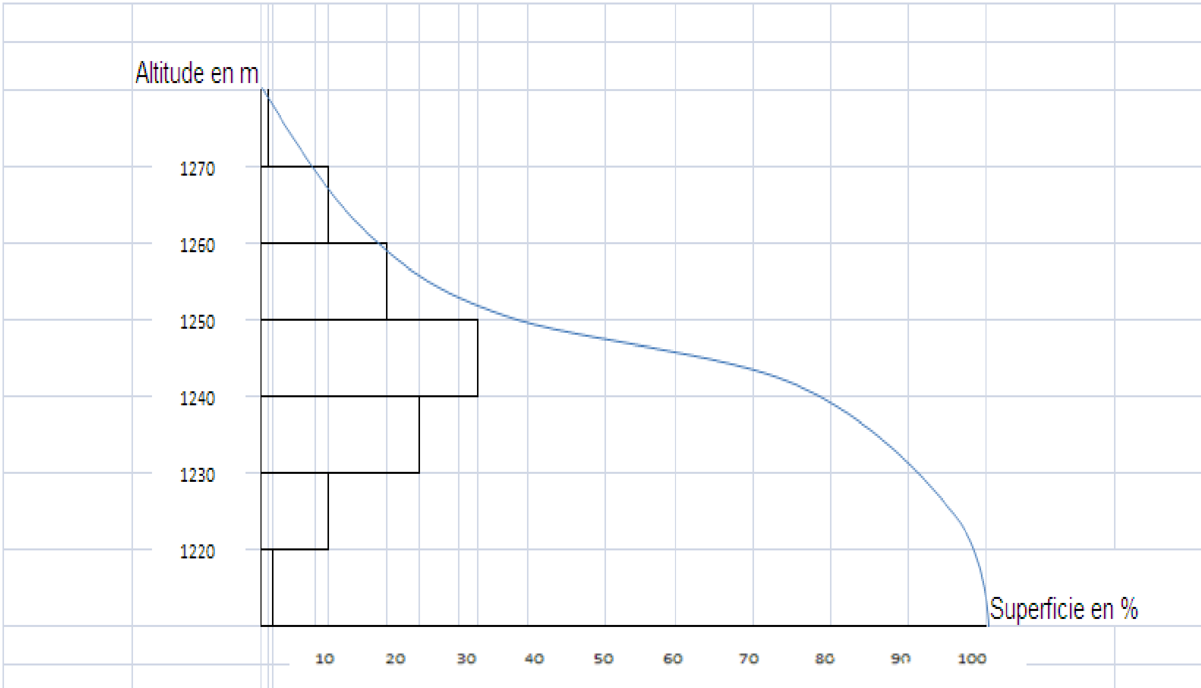

Fig. 2. hypsometric distribution and altimeter Kisanga II

¾ of the surface of the basin between the elevations 1220 m and 1250 m with a slightly marked maximum vertical frequency of 1245 m. the higher altitude areas below 1255 m or 1220 m are 6.5% and 5.4% of the area and has more or less steep slopes.

2.5 Mid Slope

The average percentage is the ratio between the difference of the extreme altitudes of the watershed and the length of the equivalent rectangle. It is 2.9 ‰ (equivalent 3 ‰). It is more or less in the southern part.

2.6 Drop Index

This is most significant since: it is the sum of the square roots of the average slopes of each of the surface elements between two successive contours (ci-1 ...) weighted by the interested surface (a_1) and divided by the square root of the length (L) of the equivalent rectangle.

$$Ip = \sum_{i}^{n} \sqrt{a_1} \text{ (ci-ci-1/}\sqrt{L} \text{ or h/li}\times 100$$

For the basin, it is equal to 0.03165 (relatively high). Fort at the height of 1228 m and 1225 m to 1223 m very little; synonymous with the slower speed. This value is close can be a bit equal to that calculated for a normal pool. From 1223 m above sea level, the section is more or less regularly until the outlet.

2.7 Long Profile

Draw the longitudinal profile from the most distant source of the outlet would give a false picture of the river profile. Indeed, the surging waters of the high peaks along relatively short slopes and the river system really take shape within walking distance of the vertices but to the general altitude of 1228m.

However, it has two stages: high ± slope of the source at the altitude of 1225 m and then regularly to the outlet. Time low water concentration, however, the flow is hindered at some point in the swampy area.

2.8 Drainage Coefficient

It is defined as the ratio of the total length (L) of the river and its tributaries on the total area (A) of the watershed. It is given by the average length of the river system in Km / Km^2 of the surface of the basin. The river is only of order 1 (containing a single stream), its coefficient is 0.024 km / km^2; relatively loose.

2.9 Evaluation Of Reserves

Observing the curve, we note that the flow rate reaches its maximum 17 January 2014 then tapers asymmetrically with respect to the concentration of water.

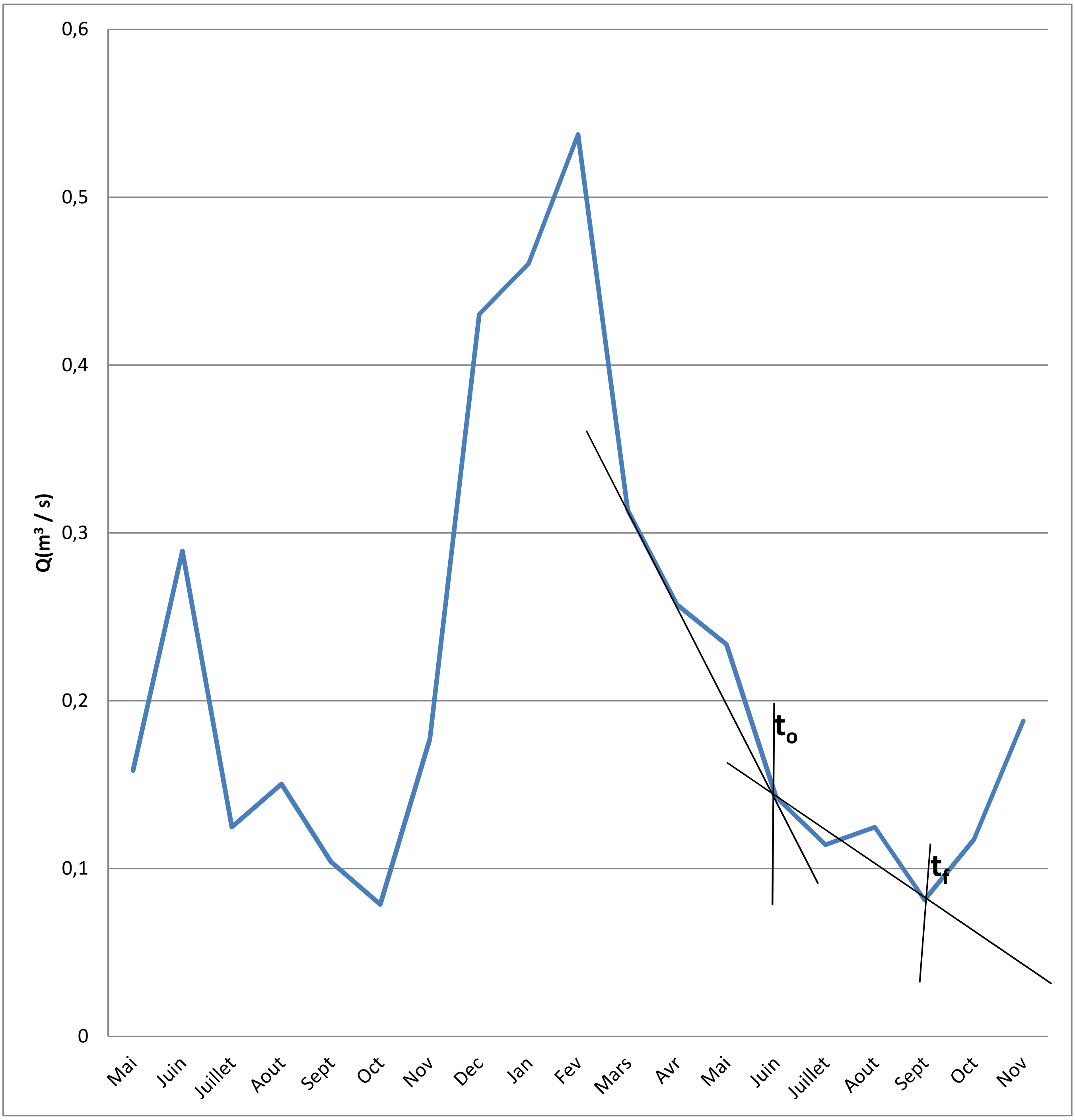

Fig. 3. Hydrogram of flood of Kisanga II (2014)

The depletion curve shows windings which could be interpreted as the result of the heterogeneity of the groundwater basin and the sides of the riverbed. Indeed, the water of the web coming into the stream by various rates due to braking and release the locations of different permeability materials. [5]

One can note a change in flow with irregularity on the recession curve until the period begins on unaffected regime.

To facilitate the problem, it was proceeded to eliminate abnormal points. The intersection of the tangent to the curve with the decline due to depletion corresponds to the dry period. The orthogonal projections of the point on the axis x-coordinates and determine the time origin respectively (to) and corresponds to Q_o (flow rate of unaffected period). That is to say, in which the stream is fed either by surface runoff or hypodermic but only by the slick that drain.

It uses a most common method, whereby the receding floods of each component of the semi-logarithmic hydrogram ordinate the flows and arithmetic on the abscissa time. This gives straight to the recession curve. Graphically decomposed by subtracting the coordinates [6]

- The day (to) begins the unaffected plan is the 23/05/2014: the stream is then supplied solely by the web (x-axis);
- The flow (Q_o) is the time (to): orderly.

The various stocks were determined after calculating the coefficients of dry α, β according to the different characteristics of the aquifer.

The drying coefficient can be obtained by applying the formulas MAILLET and TISON, WERNER and DUNSQUIT.

Q_t=$Q_o e^{-\ t}$ (1)

$Q_{t\,=}\ Q_o/(1+\beta t)^2$ (2)

Q_t: flow in the rivers after time t (m^3 / s)

Qo: river flow at time to (m^3 / s)

t: time in days counted from the time up to days when we have the throughput Qt

e: base of natural logarithms

α: depletion coefficient according MAILLET

β: depletion coefficient according TISON, WERNER and DUNSQUIT.

By formula (1)

$\ln Qt = \ln Q_o e^{-\ t}$ (2)

α = lnQo - lnQt / 0,434t (3)

By formula (2):

$Q_t = Q_o / (1 + \beta t)^2$ (4)

$1 / \sqrt{Qt} = (1 + \beta t) / \sqrt{Q_o}$ (5)

$\beta= \frac{\sqrt{Qo}/\sqrt{Qo-Qt}}{t}$ (6)

α and β may also be determined graphically from the formula

The regulatory reserve $V_R=\int_o^t Qoe^{-\ t}dt$= -Qo/□ $[e^{-\ t}]_o^t$

The total reserves VT=$\int_o^\infty Qoe^{-\ t}dt = -Qo/\ \ [e^{-\ t}]_o\infty$

The permanent reserve $V_{P\,=}V_T$-V_R=$Q_o[e^{-\ t}]o\infty$

T is the time in days between the beginning and the end of the system unaffected, according hydrograph, t = 112 days.

The angular coefficient α gives a value of 6.6 10^{-3} / day.

$Q_o = 0.19\ m^3/s$

$Q_t = 0.09\ m^3/s$

$V_R = 11.8\ 10^6\ m^3$ or 91.6 mm

$V_T = 24.8\ 10^6\ m^3$ or 191.9 mm

$V_P = 12.9\ 10^6\ m^3$ or 100.3 mm

From the formula (2)

$V_R = Qt/(1+\beta t)^2\ dt = -Qo/\beta[1/1+ \beta t]_o^t$

$V_T = -Qo/\beta[1/1+ \beta t]_o\infty$

$V_P = -Qo/\beta[1/1+ \beta t]_o\infty=V_T=V_R$ β= 4.04 10^{-3}/day

$V_R = 12.6\ 10^6\ m^3$ or 97.5 mm

$V_T = 40.6\ 10^6\ m^3$ or 313.5 mm

$V_P = 27.9\ 10^6\ m^3$ or 216.02 mm

3 DISCUSSION

These reserves are real for tablecloths impermeable bedrock which is exposed in the bed of the stream. In case we bedrock aquifers which are not flush with the base of the trough, all reserves are underestimated unless the regulatory reserve.

When meeting with tablecloths impermeable bedrock outcropping at the bottom of the bed of the stream, if the maximum aquifer does not coincide with the start of drying, all reserves are underestimated [5]. It sets the maximum level of the aquifer in April gold, our work fixed at the beginning of drying (month of May) which clearly states that specified reservations are not to be underestimated.

Reserves calculated by the two methods of the same order of magnitude, but nevertheless their validity is set by calculating the dispersion € by the formula: €= $\frac{\mathrm{Qob}-\mathrm{Qth}}{\mathrm{Qob}} \times 100$: Qob and Q_{th} the average of observed rates and those of theoretical speeds.

According to the formula of MAILLET, €= 52.26% with TISON, WERNER and DUNSQUIT € = 68.89%.

So this is the method of MAILLET showing the lowest dispersion. If we take the results found by the two methods we can calculate the relative differences between different comparison results from the formula.

$E_R = \frac{Vtison-Vmaillet}{Vtison} \times 100$

It is found from this formula that the relative differences are 6.05% for regulatory reserves; 38.7% of total reserves, 53.6% for permanent reserves.

To determine the regulatory capacity of a web from MAILLET, we calculate the following parameters: d_v.

$d_v = \frac{VR}{A} \times 100$ (index emmagasinement)

d_v = 11.8.106103 / 12.9.106 = 91.64 mm.

4 CONCLUSION

The Watershed of Kisanga II has a compact form; water could take a long time to reach the outlet. The regulatory capacity of the aquifer Kisanga II is determined by:

O The index of emmagasinement dv = 91,64mm. Considering that the amount of water returned to the river by the table is the same as that which was provided to him by the infiltration in the same hydrological period (2014-2015), in this case:

$I_e = d_v / A_p \times 100$

This relationship applied to our pool, effective infiltration is 7.05%. This shows that the Kisanga II pool is not very permeable. Now, in the balance equation, it was found at 9.28%. This may be due to the distance between the weather station of Gécamines in the study site (variation of rainfall according to the latitude where according to distance from the epicenter of the storm).

Change rate expressed by the relationship $n = V_R / V_T$ is 0.477 equivalent to 0.48.

The renewal period which is the inverse of the change rate = V_T / V_R = 2.09 is equivalent to 2.1. Note that: When improperly exploits Kisanga II slick, that is to say higher operating at 11.9 m^3 / year you must let it rest for about 2 years it is reconstituted. This indicates the optimal operating conditions of the aquifer Kisanga II.

REFERENCES

[1] LAMBINON, J. (1981): Quality of Walloon Basin flowing waters of the Meuse. Bruxelles, Belgium
[2] KASONGO N., (2008): Water and forests of DR Congo "a geostrategic challenge 'Harmattan, Paris.
[3] CASTANY G., (1968): Exploration and Exploitation of Groundwater. Ed. Dunod 717p.
[4] ALONI K., (1975): Indice de croissance de l'espace urbain sur la pluviosité, Géo-eco-trop pp. 125-130
[5] BEUGNIES A., (1954): Ground water around Elizabethville and related phenomena of weathering. Ed. Annals of Mines service and Geographical and Geological Service, 54 p.
[6] CASTANY G., (1998): Hydrology, Principles methods 2e ed. Dunod Paris
[7] KASONGO N., MBUYU N, LUNDA L., ILUNGA L., (1995): Hydrological characteristics of the watershed of the Upper Kafubu. Ann. Fac. Polytechnic (UNILU Zaire). Flight. 5 No. 1, p 45-53.
[8] FOURMARIER P., (1958): Hydrology, Introduction to the Study of water intended for human food and Industry. Ed. Masson and Cie.294p Paris.
[9] GUISCAFRE J., J-C. OLIVRY (1975): The River Basin SANAGA ed. Office of Scientific Research hydrological Monograph, 350 p.
[10] REMENIERAS G., (1960): The hydrology engineering, national laboratory collection of Hydraulics, Eyrolles, PP 50-102