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Hydrological Study Of The Catchment Area Of The Kinsenda River

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Abstract: In mining, the unwatering of the aquiferous formations and the control of these last imply a good *knowledge of local geology and a perfect approach of the hydrological factors which condition the mode of subsoil waters (supply of water in aquifers, fluctuation of the piezometric levels, etc). This approach will concentrate on the morphometric study of the catchment area of the Kinsenda river; the determination of the characteristics of relief and itshydrographic network.*
The morphometric, hydrographic and hypsometric study from the catchment area of the Kinsenda river brought out the following elements:

- *a perimeter of 80.505 km and a surface of 221.522274* km^2 *;*
- *a coefficient of Gravelius of 1.53;*
- *uneven specific of 64 m with the average slope of 4.18 %;*
- *a density of drainage of 0.46* km^{-1} *;*
- *a frequency of the talwegs of order 1 of 0.22* km^{-2} *;*
- *a report/ratio of junction of 2.24 and one report/ratio length of 0.33.*

The piezometric charts brought out the following elements:

- *General pace of groundwater does not vary much in the course of time and the configuration of the curves isopiezes on our two piezometric charts is almost coarsely the same one, however the fall of piezometric surface shows significant values during the interval of time considered;*
- *The direction of the general flow of the groundwater (a flow influenced by the effects of pumping out of the level 285Ml) is centered on direction E-W; these various interpretations relate to the chart of high waters and that of low waters;*
- *The shape of the curves isopiezes indicates the existence of several different sectors with hydrodynamic caracteristics in the groundwater, So, that, zone of study was subdivided in five sectors (Central area, Western area, Eastern area, Southern areaand Northern area).*

Keywords *: catchment area, piezometry, hydrographic network, morphometry, relief, geology, hydrogeology, isopieze.*

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I. Introduction

The practical problems of hydrology related to or aim generally an extent of ground limited to the catchment area of a river in a given point of this one. The area catchment in a point or more precisely in a cross-section of a river is defined like the totality of the topographic surface drained by this river and its affluents with the upstream of the cross-section considered to continue their way towards the downstream; all the flows occurring in this surface must cross the cross-section considered to continue their way towards the downstream (Remenieras, 1980). The Kinsenda river and the Luina river are the two significant rivers which delimit the mining sector of Kinsenda and they are thrown on the Western Lubembe river. We think that the hydrology and the hydrogeology of the mine of Kinsenda remain controlled by the hydrodynamic behavior of the catchment area of the Kinsenda river. The brook of Kitotwe belongs to the catchment area of the river Kinsenda (fig.1).

II. Materials and Methods

In the harvest of the data, we had used:

- images SRTM;
- piezometric survey;
- piezometric probe;
- observations on the ground.

For data interpretation, we have used the following software:

- MapInfo Professionnal;
- Arc GIS;
- Google Earth;
- Surfer;
- MS office.

III. Results

3.1 Location of study area

The catchment area of Kisenda river is located in the southern part of Democratic Republic of Congo, near the border of Zambia. As the crow flies, the centroid of Kisenda river's catchment area is situated 86.55km from Lubumbashi and 41.95km from Chingola in Zambia.
The figure 1 shows the location of the study area.

Figure 1: Location of study area

3.2Morphometric characteristics

As known as Laborde (2009)[1], the purpose of the use of morphometric characteristics is to condense in a certain number of quantified parameters, the function H = F (x,y) inside the catchment area (H altitude, X and punctual coordinate there of the catchment area).

3.2.1 Characteristics of the provision in the plan

The surface of the catchmentareais one of the most important of caracteristics.We calculate it by planimetry on the survey map once limits are defined.Each catchment area is separated from others by following the ridge line which share waters flow in different directions. Pratically, the limits on survey map, the limit follows those ridge lines which border the catchment area and cross the river only to the right side of that section. (Remenieras, 1980)[4].

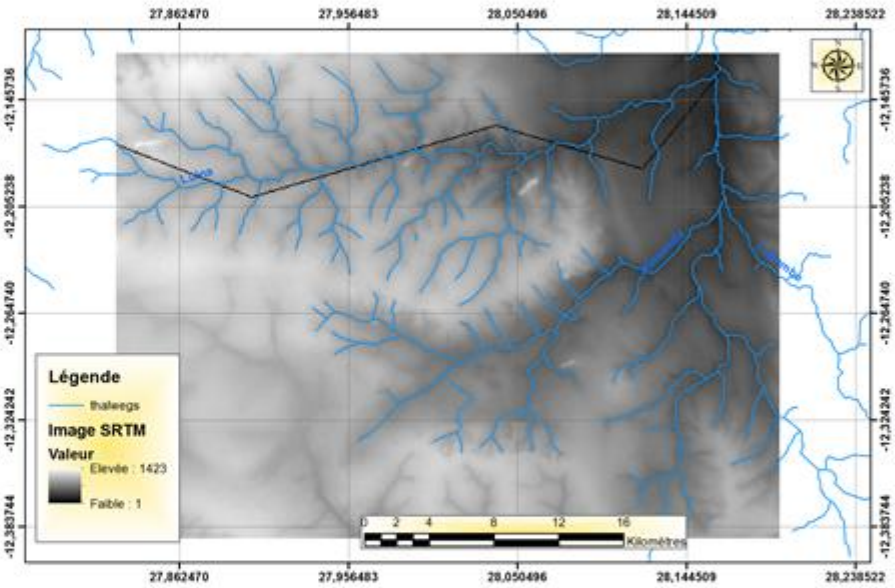


Figure 2: Kinsenda regional hydrographic network map

Figure 2: shows the delimitation of the area catchment of Kinsenda riveron the regional topographic map by taking as discharge system the junction of the Kinsenda river with the Lubembe river.

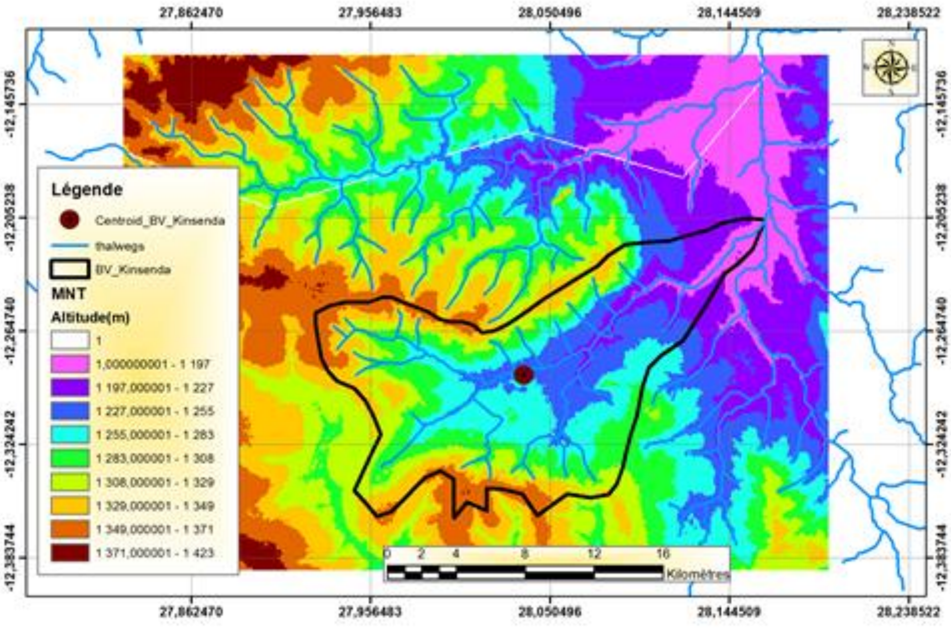


Figure 3: Delimitation of the area catchment of Kinsenda on the regional topographic map

Various characteristics length are used; the first and one of the most used are the perimeter P of the catchment area.

The catchment area of Kinsenda has a perimeter of 80.505 km and a surface of 221.522274 km^2.

The length of the longest talweg (the Kinsenda river) $l_t$is of 30.188 km, the biggest length between two extreme points L is of 28.211 km, the greatest width perpendicular to L is of 14.288 km and outdistances it between the discharge system and the centre of gravity of the catchment area l_g is of 16.428 km. The report/ratio enters L and l is of 1.97 and

the characteristic of the most used form is the coefficient Kc de Gravelius. It is defined as the report/ratio of the perimeter of the area catchment in the perimeter of a circle having even surface (also called coefficient of capacity):

$$K_c = \frac{P}{2\sqrt{\pi A}} \quad (1)$$

A: the surface of the catchment area;
P its perimeter.

The catchment area of Kinsenda presents a coefficient of Gravelius of 1.53 what translates a basin of form lengthened.

The perimeter P is not generally used directly but through values which derive from it, like the length L of the equivalent rectangle. One defines the equivalent rectangle as the rectangle length L and width l which has even surface and even perimeter which the catchment area, that is to say using the equation:

$$P = 2.(L + l)\ et\ A = L.l \quad (2)$$

In practice, the simplified formulas of L and l given by Remenieras (1980)[4] are function of the index of compactness Kc:

$$L = \sqrt{A}\frac{K_c}{1.12}(1 + \sqrt{1 - (\frac{1.12}{K_c}}) \quad (3)$$

$$l = \sqrt{A}\frac{K_c}{1.12}(1 - \sqrt{1 - (\frac{1.12}{K_c}}) \quad (4)$$

The formulas 3 and 4 applied to the catchment area of Kinsenda, gives an equivalent rectangle of 34.184 km of length and 6.480 km of width.

3.2.2 Hypsometric characteristics

In practice, one is not interested in average altitude but rather in dispersion of altitudes(Remenieras, 1980[4]; Musy et al., 1998 [2]; Musy, 2005[3]; Laborde, 2009[1]).

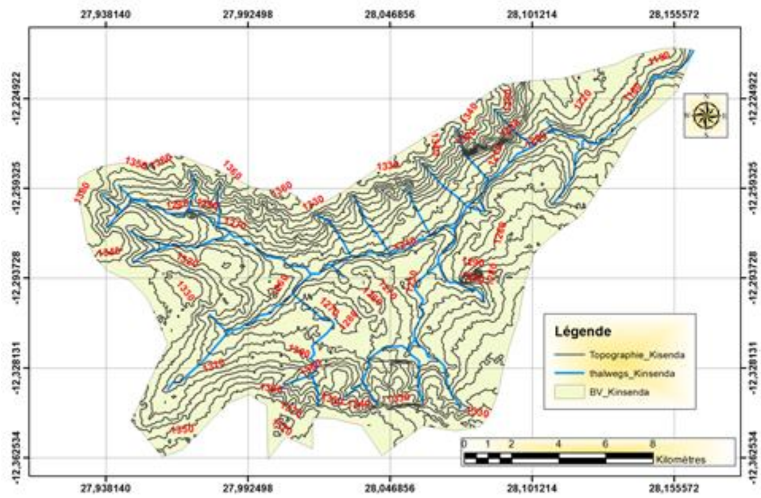


Figure :4 Distribution of altitudes on the catchment area of Kinsenda

The Map of figure 4 shows various surfaces corresponding to various classes of altitude and figure-5 presents the histogram and the hypsometric curve of the catchment area of the Kinsenda river.

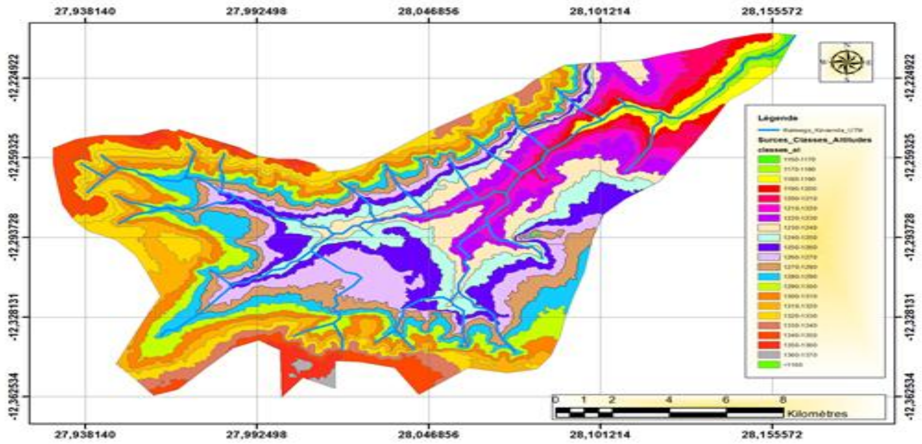
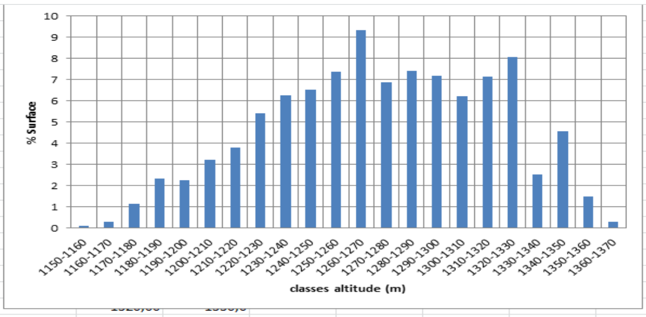


Figure 5: Map of surfaces of the various classes of altitudes

Classes_alt	ai(%)	Hci(m)	ai_cum(%)
1150-1160	0,10697176	1155	0,10697176
1160-1170	0,31716443	1165	0,42413619
1170-1180	1,14358715	1175	1,56772334
1180-1190	2,3385974	1185	3,90632074
1190-1200	2,26116213	1195	6,16748287
1200-1210	3,2205007	1205	9,38798357
1210-1220	3,82143216	1215	13,2094157
1220-1230	5,43176624	1225	18,641182
1230-1240	6,27611269	1235	24,9172947
1240-1250	6,54356925	1245	31,4608639
1250-1260	7,38895804	1255	38,849822
1260-1270	9,34104355	1265	48,1908655
1270-1280	6,89532598	1275	55,0861915
1280-1290	7,42146789	1285	62,5076594
1290-1300	7	1295	69,6985542
1300-1310	6,21354737	1305	75,9121015
1310-1320	7,13222168	1315	83,0443232
1320-1330	8,08024171	1325	91,1245649
1330-1340	2,52456045	1335	93,6491254
1340-1350	4,5543506	1345	98,203476
1350-1360	1,48030742	1355	99,6837834
1360-1370	0,3162166	1365	100
tot	100		



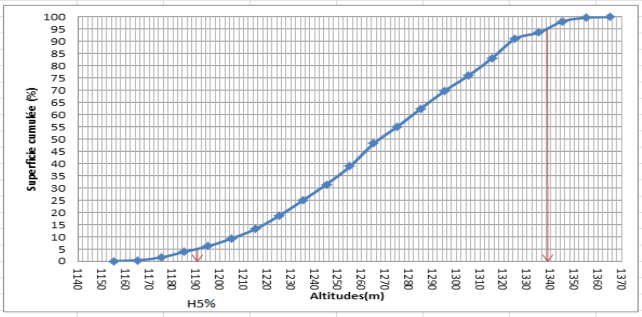


Figure 6: Histogram and hypsometric curve of the basin of Kinsenda

The uneven one D is given by the equation:

$$D = H_{5\%} - H_{95\%} \qquad (5)$$

The hypsometric curve gives $H_{5\%}$ of 1190 m and $H_{95\%}$ of 1338 m. Uneven D is of 148 m.

3.2.3 Indices of slope

The idea first which comes to mind is to characterize the slopes by their average value I balanced by surfaces. Either D the équidistance of the level lines, or d_j the average width of the band jincluded between the datum linesj and j+1and the average length of this band is l_i. The average slope n_j on this tape is : $nj = \frac{D}{d_j}$ who has like surface $a_j = d_j \times l_j$.

The average slope I balanced by surfaces east given by the equation:

$$I = \frac{D \sum l_j}{A} \qquad (6)$$

If L_c is the overall length of the level lines equidistant of D, the average slope I has as an expression : $I = \frac{DL_c}{A}$. The figure 6 shows the most dominant level lines on the catchment area of Kinsenda.

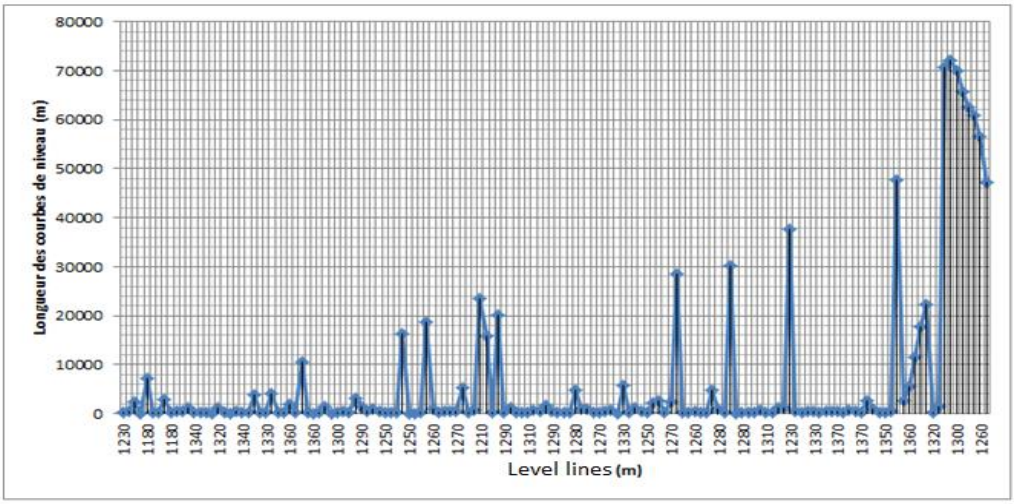
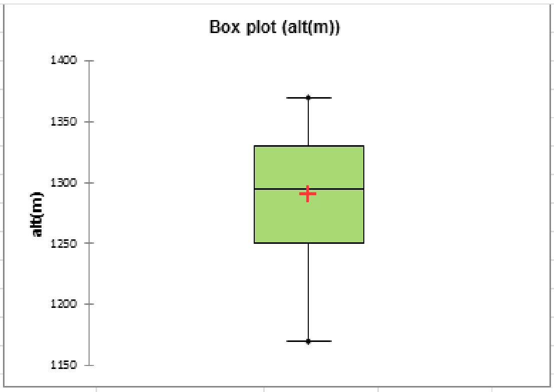


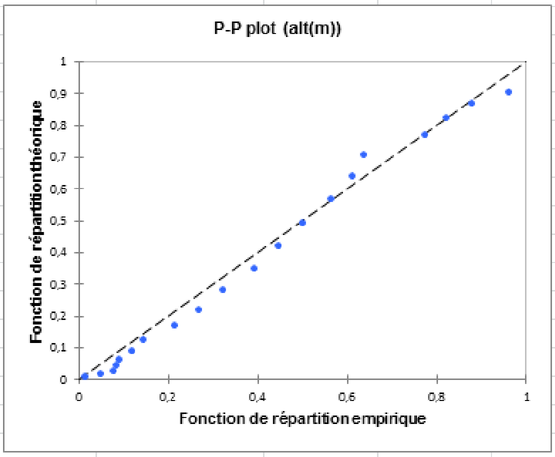
Figure 7: Level lines according to their lengths on the catchment area of Kinsenda

Table 1 shows the statistical synthesis of the variable altitude on the catchment area of Kinsenda.

Table1: Statistical synthesis of altitude on the catchment area of Kinsenda

Statistique	alt(m)
Nb. d'observations	146
Nb. de valeurs manquantes	0
Minimum	1170,000
Maximum	1370,000
Eff. du minimum	2
Eff. du maximum	6
Amplitude	200,000
1er Quartile	1250,000
Médiane	1295,000
3ème Quartile	1330,000
Moyenne	1290,548
Variance (n)	2810,659
Variance (n-1)	2830,043
Ecart-type (n)	53,016
Ecart-type (n-1)	53,198
Coefficient de variation	0,041
Asymétrie (Pearson)	-0,418
Asymétrie (Fisher)	-0,422
Asymétrie (Bowley)	-0,125
Aplatissement (Pearson)	-0,704
Aplatissement (Fisher)	-0,686
Ecart-type de la moyenne	4,403
Borne inf. de la moyenne (95%)	1281,846
Borne sup. de la moyenne (95%)	1299,250
Ecart-type de la variance	332,372
Borne inf. de la variance (95%)	2276,858
Borne sup. de la variance (95%)	3613,699
Erreur standard(Asymétrie (Fisher	0,201
Erreur standard(Aplatissement (Fi	0,399
Ecart absolu moyen	44,658
Ecart absolu médian	35,000
Moyenne géométrique	1289,445
Ecart-type géométrique	1,043





Test de normalité

2.Méthode	p_value	H0
Shapiro-Wilk	6,5577E-05	Rejetée
Jarque-Bera	0,02657637	Rejetée
Agostino-Pearson	0,00567024	Rejetée

The distribution of altitudes in the catchment area of the Kinsenda river is not normal.
With the level lines of figure 3, the équidistance D is 10 m and the overall length of the level lines Lc is of 918226 m either 918.226 km.
The average slope I of Kinsenda is 0,0418 either4,18 %.
Roche quoted by Remenieras (1984)[4], Musy (2005)[3] and Laborde (2009)[1], proposed an index of slope easier to calculate than the index of average slope: $I_p$is the average of the square root of the slopes measured on the rectangle equivalent, and balanced by surfaces.
This index east defines by the equation:

$$\beta_i = \frac{x_i}{L} \text{ and } I_p = \frac{\sqrt{D}\sum\sqrt{\beta_i}}{\sqrt{L}} \quad (7)$$

With D the équidistance of the level lines, L the length of the rectangle are equivalent and X_i the spacing between two successive level lines whose sum is worth L.
The index of Rock proposed by Remenieras (1984)[4], Musy (2005)[3] and Laborde (2009)[1], takes too a long time to evaluate for fast studies, this is why another index was proposed: the total index of slope I_g given by equation 8.

$$I_g = \frac{D}{L} \quad (8)$$

With D the uneven one given by the equation (5) and L the length of the rectangle are equivalent. The catchment area of Kinsenda has a total index of slope of 0.0043.
Laborde, 2009[1] shows that the index of Rock $I_p$and the total index of slope $I_g$are bound by a relation of the type $I_g = 0.8I_p^2$ with a coefficient of correlation of about 0.99.
Applied to the catchment area of Kinsenda, the slope of Rock is 0.0736 is 7.36 %.
The index $I_g$decrease for the same basin when surface increases, it is difficult to compare basins of different sizes. Uneven specific the D_s does not present this disadvantage: it derives from the total slope I_g by correcting it of the effect of surface (equation 9).

$$D_s = I_g\sqrt{A} \quad (9)$$

With the total index of slope of 0,043, the uneven specific one is 64 m for the basin of Kinsenda.
The map of figure 7 gives the distribution of the slopes on the catchment area of Kinsenda.

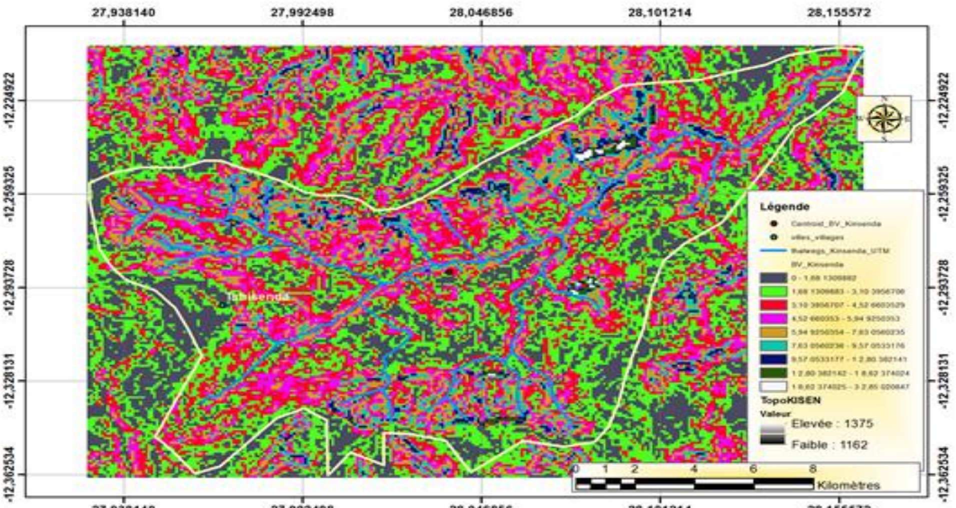


Figure 8: Distribution of the slopes on the catchment area of Kinsenda

3.3 Characteristic hydrographic of the basin
The hydrographic network is consisted of the whole of the channels which drain surface water towards the discharge system of the catchment area.
The hydrographic network can be characterized by three elements: its hierarchisation, its development (numbers and lengths of the rivers) and its profile longitudinally.

To quantify the ramification of the network, each river receives a number function of its importance. This classification, called order of the river, differs according to authors. Among all these classifications, we adopted that of Strahler (Musy, 2005[3]; Laborde, 2009[1]). Figure 8 gives the classification of hairy basin of Kinsenda.

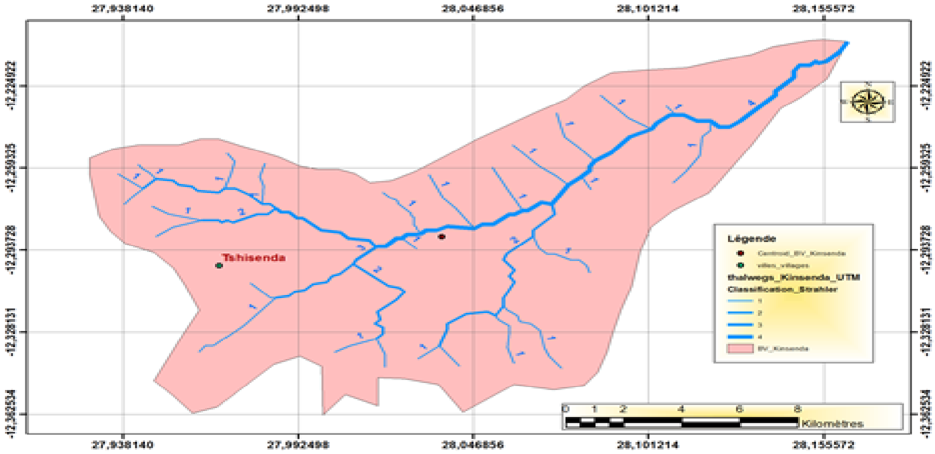


Figure 9: Classification of the talwegs according to Strahler

Table 2 gives a summary of the results of classification of the talwegs of the basin of Kinsenda.

Table 2 : summary of the results of classification of the talwegs

Thawegs i	Numbers i	Length I in km
	26	49.650
	5	25.494
	2	5.298
	1	20.815
Total	34	101.256

Horton in Musy (2005), set up empirical laws which connect the number, the average length and the order of the rivers. For a homogeneous area catchment, the report of junction

$R_c = \dfrac{N_i}{N_{i+1}}$ is appreciably constant. It is the same for the report length $R_l = \dfrac{l_i}{l_{i-1}}$.

Figure 9 drawn up starting from table 2 allows the determination of R_c and R_l.

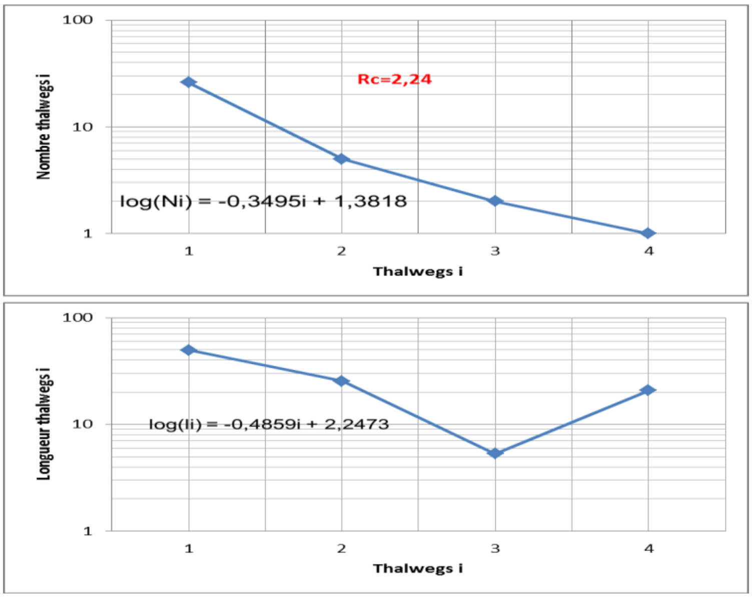


Figure 10: Laws of Horton applied to the catchment area of Kinsenda

The catchment area of Kinsenda presents a report of junction of 2,24 and one report length of 0,33.
To characterize the hairy hydroraphique one, other parameters exist like the density of drainage (equation 10) and the frequency of the talweg of order 1 F_1(equation 11).

$$D_d = \frac{\sum l_i}{A}(km^{-1}) \qquad (10)$$

$$F_1 = \frac{N_1}{A}(km^{-2}) \qquad (11)$$

The catchment area of Kinsenda presents a density of drainage of 0,46 km^{-1} and a frequency of the talwegs of a nature 1 of 0,22.

3.4 Hydrogeologic characteristics of the catchment area of Kinsenda

3.4.1. Geology of the catchment area

The layer of Kinsenda is located at the South-eastern edge of the dome of Luina. It is a sedimentary layer of Zambien type pertaining to the category of the layers located in the more or less coarse arenites, that one meets primarily on the side of the anticline of Kafwe, since Bwana mkubwa, nearly Ndola(Zambie) until Kinsenda while passing by Mufulira(Zambie) and Lubembe. On a purely explanatory basis, the following map(figure 10) shows the geological formations which level in the area of Kinsenda.

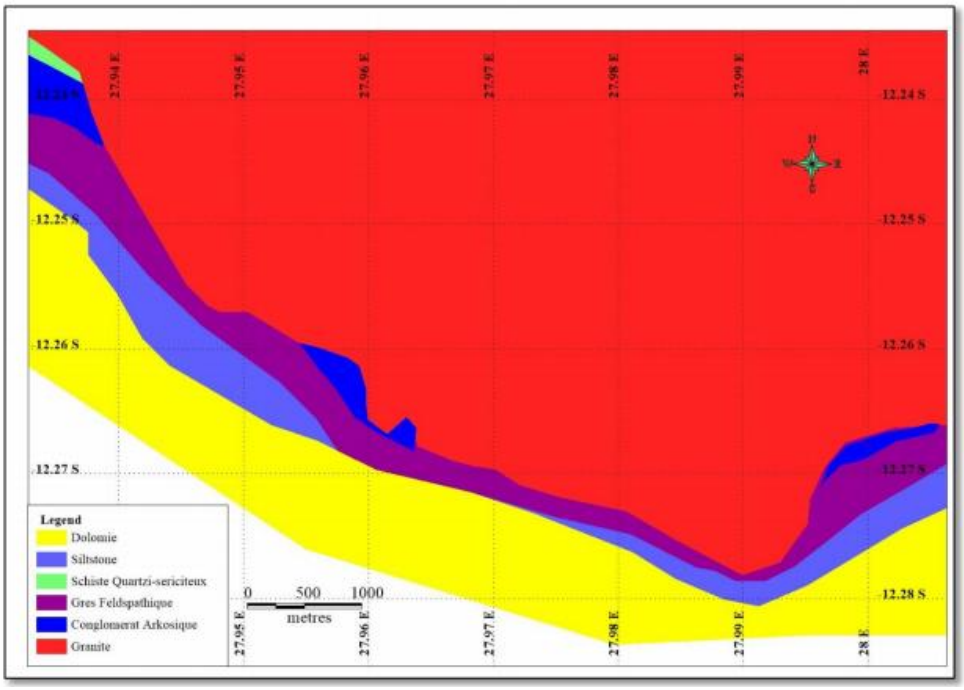


Figure 11: Geology of the catchment area of Kinsenda

3.4.2 Piezometry carried out in the catchment area

The analysis of the piezometric variations in plan and profile makes it possible to know the minimal and maximum values piezometric level, like their annual or interannual average amplitude. It also provides a good estimate of the natural water supply of the aquifer and space-time evolution of its reserves, while characterizing, in particular, of the homogeneous sectors with respect to the refill and discharge (Gilli and Al, 2008).

For the realization of the piezometric cartography, we carried out a campaign of ground between April and September 2014. Measurements of the piezometric level were taken in the mining boreholes. With all these measurements and other catches before by the service of géologie/KICC, we plotted various diagrams of interpretation.

In the mining perimeter of Kinsenda, we inventoried 17 drillings (not stopped) for the catch of measurement of piezometric levels. These drillings, of variable depth were used for the catch of measurements of the weekly and monthly levels. Table 3 gives the geographical co-ordinates of the surveys like their respective depths.

Table 3: Coordinates of the various points of drilling and piezometric heights observed

Code_sondage	Long(°)	Lat(°)	Alt(m)	Juil	Aout	Sept	Oct	Nov	Dec	Janv	Feb	March	April	May	June
KND 80 (B)	604726,6	8644478,8	1323,54	1104	1104	1099,495	1096,22	1095,7	1095,6	1094,9	1092,6	1096	1095	1095	1096
KND 85	604359,3	8644468,9	1324,862	1144	1144	1142,372	1141,95	1141,9	1141,9	1143	1143,2	1144	1143	1143	1143
KND 105	605619,6	8644011,7	1298,557	1200	1200	1197,502	1196,65	1196,1	1196,1	1192,7	1193,2	1195	1195	1194	1194
KND 106	603966,8	8645194,6	1354,45	1191	1190	1190,08	1189,09	1188,8	1188,8	1188,8	1188,4	1189	1189	1189	1188
KND 126	604529,8	8643958,6	1305,557	1133	1133	1132,847	1134,89	1133,7	1133,7	1131,3	1130,8	1131	1133	1144	1138
KND 179	603976,2	8644330,4	1317,264	1123	1118	1118,279	1116,64	1115,9	1115,9	1116,6	1110	1111	1111	1116	1115
MKD 007	604404,1	8644252,6	1315,407	1097	1098	1096,912	1096,54	1095,4	1095,4	1096	1094,2	1098	1095	1096	1095
MKD 049	605306,1	8643866,1	1295,885	1200	1199	1199,395	1199,16	1199,5	1199,5	1198,6	1198,6	1199	1200	1200	1200
MKD 051	605672,1	8643895,1	1299,803	1196	1197	1193,548	1191,1	1190,7	1190,7	1187,3	1187,4	1191	1190	1189	1190
KND 122	604371,4	8644303,1	1317,295	1283	1283	1281,845	1280,89	1280,6	1280,6	1279,8	1279,9	1280	1281	1282	1283
KND 128	604372,1	8643791,1	1301,275	1231	1231	1230,715	1230,87	1230,3	1230,3	1237	1236,7	1237	1241	1243	1245
KND 144	604439,1	8643876,1	1302,301	1264	1265	1265,006	1263,78	1262,5	1262,5	1260,1	1259,2	1261	1262	1262	1262
KND 149	605210,5	8643565,8	1289,361	1267	1267	1267,791	1266,48	1264,9	1264,9	1261,6	1260,9	1263	1264	1262	1261
MKG 3	605807,9	8644166,3	1310,02	1238	1238	1238,305	1224,08	1223,1	1223,1	1224,4	1224,4	1226	1226	1223	1224
MKG 10	605891,3	8644376,3	1311,59	1265	1266	1265,725	1267,42	1267,1	1267,1	1264,5	1265,1	1264	1266	1266	1267
MKG 11	605834,2	8644274,8	1307,94	1268	1268	1267,465	1266,93	1267,3	1267,3	1266,9	1266	1265	1267	1268	1270
MKD 55	605767,5	8643962,5	1304,57	1185	1185	1185,025	1185,04	1184,4	1184,4	1182	1183,1	1184	1184	1183	1184

Figure 12 shows the space distribution of drillings on the geological map

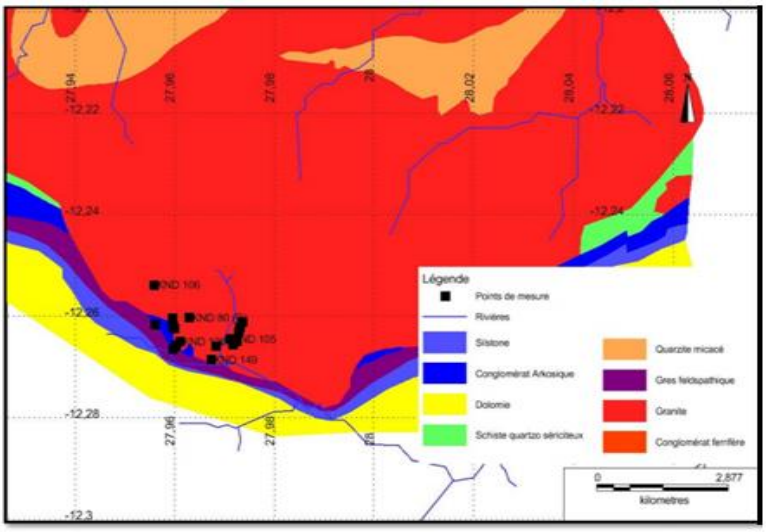


Figure 13: Distribution of drillings on the geological map
We studied the evolution of the piezometric levels in each survey of measurements according to time.

The figure 13 shows the evolution of the piezometric levels in the various surveys according to time.

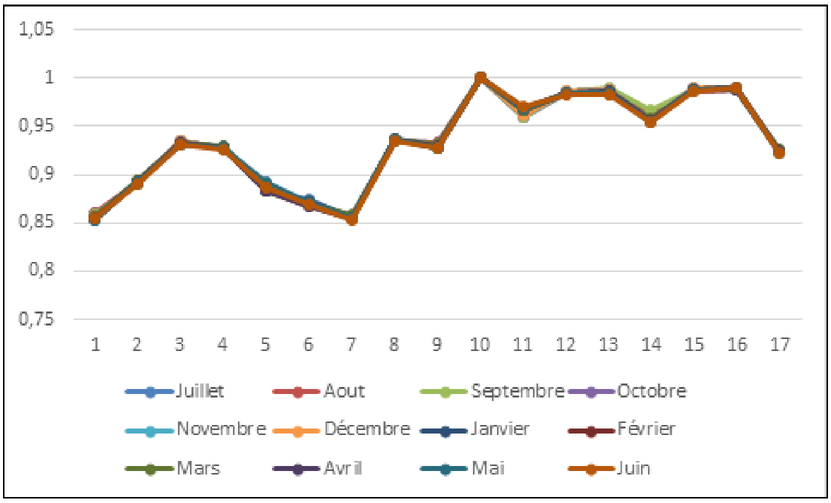


Figure 14: Evolution of the piezometric levels in the various surveys

3.4.3 Piezometric map

The piezometric map, established with the data on the piezometric levels, represent, at a given date, the spatial distribution of the loads and hydraulic potentials. They are background documents of the analysis and schematization of the capacitive and conducting functions of the tank and hydrodynamic behavior of the aquifer (Castany, 1982). The piezometric studies require to have a very precise levelling of the points of observation (well, drillings, piezometers, sources) which makes it possible to guarantee the precision in the establishment of a piezometric map.

This one is traced by interpolation between the raised dimensions, on the basis of curves hydroisohypses(lignes of equal altitude of the piezometric surface) whose quality and équidistance will depend on the density of the points of measurement and the scale of adopted study (Gilli and Al, 2008)

Considering the rather reduced number of points of measurement and their irregular distribution on the ground, the piezometric layout of the charts (in high waters and low waters) was carried out using the piezometric levels taken in all the surveys of mesure.D' after piezometric measurements of July 2013 until June 2014; We established two piezometric charts of which the first for high waters (figure 14) and the second for low waters (figure 15).

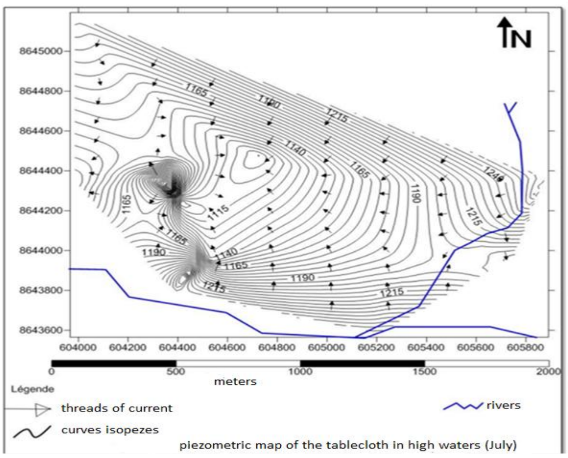


Figure 15: Piezometric map of high waters ofthe groundwater ofKinsenda river

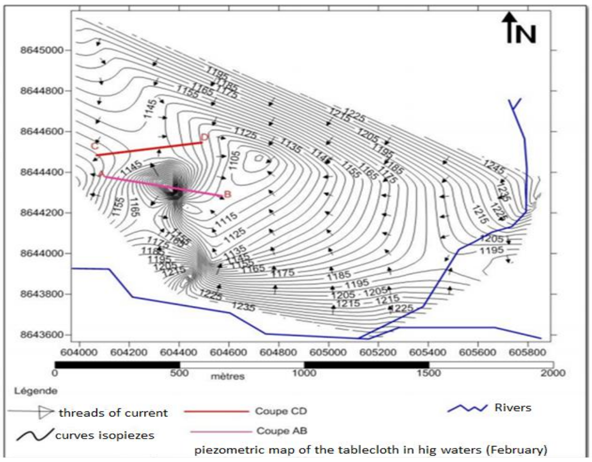


Figure 16: Piezometric map of low waters of the groundwater of Kinsenda river

Two piezometric profiles (profiles AB and CD on figure 15) were carried out on the map of low waters in order to arise the piezometric anomalies being able to exist precisely in the North-western and Southern part of this sector. These two profiles were traced so as to recut the anomalies.

IV. Interpretations and discussions of the results

The morphometric, hydrographic and hypsometric study from the catchment area of the Kinsenda river brings out the following elements:

- ✓ a coefficient of Gravelius of 1.53 which translates a catchment area of lengthened form which would support the evapotranspiration and the infiltration with the detriment of the streaming and also implies a rather long response time;
- ✓ a distribution of altitudes which does not follow the normal law;
- ✓ one height difference specific of 64 m with the average slope of 4.18 % which translates a catchment area with relief moderated in the second classification of the O.R.S.T.O.M in Laborde (2009)[1];
- ✓ a density of drainage of 0.46 which means that the flow on the basin reached a very limited development, and is centralized.

We noted that in the majority of the surveys, the recorded maximum piezometric dimension is with 1282.845m (at the time of the piezometric statement of July) and the recorded minimal piezometric dimension is to 1092 m (at the time of the piezometric statement of February).

The piezometric levels do not vary with the seasons, i.e. the piezometric levels low are observed during the seasons of rains (January, February and Mars) and the levels piezometric highest during the seasons dry (July, August and September). This finds its explanation owing to the fact that it rains abundantly in December, January and Févier, these precipitations are used for the réconstitution of moisture of the ground and the basement before attending an infiltration of the waterground, i.e. the response time of the waterground compared to the evolution of precipitations is long and the water arrival to the waterground can occur in the weeks or the months which follow the rainy period. By observing the table3, we see that the waterground is located at great depth, reason why piezometric levels continuous to decrease during the first months of precipitations. The increase observed in some surveys are due to the stop of certain mine pumps put aside and the transcription misreadings of the observations. The falls observed in some surveys can be the result is of a flow of the tablecloth towards the river or the result of an effect of pumping intense of pumping out of the level 285 Ml of the mine.

With the first glance of the piezometric charts, it brings out the following elements:

- ✓ the general pace of the waterground does not vary much in the course of time and the configuration of the curves isopièzes on our two piezometric charts is almost coarsely the same one, however the fall of piezometric surface shows significant values during the interval of time considered;
- ✓ the direction of the general flow of the waterground (a flow influenced by the effects of pumping of the pumping out of the level 285Ml) is centered on direction E-W; These various interpretations relate to the chart of high waters and that of low waters;
- ✓ the shape of the curves isopiezes indicates the existence of several different sectors with hydrodynamic behavior in the waterground, reason for which we subdivided our zone of study in five ares (Central are, Western are, East are, Southern are, Northern are) described in the lines which follow.

Central are

In this sector the curves isopiezes are closed again on themselves with convergent threads of current indicating that there is in the waterground a depression. This depression is caused by the effect of pumping of the pumping out carried out in the mine on the level 285 ml. The underground channels are significant and are illustrated by the threads of current which converge towards survey KND 80. The isopiezes thus draw a radial waterground with convergent nets.

Western are

In the North-western part of this sector: The curves isopièzes present irregular forms to it and their module of spacing is large compared to certain places of the tablecloth. One an abrupt and abnormal change of radius of curvature of the isopièzes where the threads of convergent current describe a certain anomaly (Of which nature notes) to put forth an assumption of explanation) in this place of the tablecloth.

In are the southern part of this sector the curves isopiezes closed again between themselves, with divergent threads of current indicating a certain anomaly. The tablecloth is radial with divergent nets. (As indicated on all the two figures above).

Southern area

In the southern part of this sector: One notices a certain divergence of the threads of current along the Kitotwe river. This makes us think of the presence of an underground drain. A little more in the center of this sector there is a convergent flow which is represented by a curve showing a concavity turned upstream of the

zone of pumping out of the mine (around survey 80B) and of the convergent threads of current. This type of flow translates a depression. The waterground is radial with convergent nets.
One sees a curve which is closed again on itself with threads of divergent current indicating a piezometric dome. waterground is radial with divergent nets.

Northern Sector

In this sector the waterground is radial with convergent nets with a constant hydraulic gradient. The radius of curvature of the isopiezes is more or less marked. The waterground is convex with arcs of circle with orientation upstream. The particularly marked tightening of the isopiezes deserves an explanation. We thought of the presence of the intercalations of the permeable and not very permeable rocks which could contribute to the reduction in the cross-section of stream discharge and which make surface piezometric cylindrical. More one moves towards the East or towards the West the curves isopièzes marry a certain slope.
The piezometric profiles carried out on the piezometric charts show the following observations:

- ✓ On piezometric profile AB traced on the part where the curves isopiezes are closed again between themselves, one notices a convexity of piezometric surface. We think that this localised variation would be due to a convexity of the substratum of the aquifer;
- ✓ On piezometric profile CD, the shape of the piezometric curve translates the presence of a piezometric dome of which we think that the cause would be the same one as that observed on piezometric profile AB.

In this study, several recommendations can be suggested to fight against the makes of water in the mine of Kinsenda:

- ✓ Our study related to the Kinsenda river. The Direction of the flow of the waterground show that the Kinsenda river recharges mainly the waterground from there

fracture North-South direction. The Kinsenda river crosses the formations schisto- dolomitic. These formations are likely of realimenter continuously there
Mine starting from their cracks if those are opened and interconnected.Il thus has there
to consider filling by an impermeable screen enters the Kinsenda river and there
waterground; But also the filling of the zone fractured to decrease the rate
of infiltration by crack.

- ✓ Establishment of a significant number of the new surveys for the taking away

piezometric measurements in order to trace better piezometric map;

- ✓ Topographically, the granitic solid mass of Luina is located at a high altitude by Report with that of the mine of Kinsenda. To have precise details on the destination of the flow of the Luina river, some piezometers must be established around granitic solid mass of Luina. The study undertaken in this work on piezometry, the tests of pumping and there determination of the hydrodynamic characteristics of the waterground of Kinsendariver allowed to have a good comprehension of the waterground and on its hydrodynamic operation.

However it would be interesting to supplement it by:

- ✓ A structural and morphological characterization detailed in order to specify extension of the waterground of Kinsenda and its probable hydraulic connection, if it exists with other aquifers of the area;
- ✓ With the present stage, our observations show a weakness to the measures of flow of Kinsenda river. We suggest however that future work will think of it problem;
- ✓ A good physicochemical characterization of subsoil waters in order to specify source of water which comes in the mine.

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