MODELING THE EVOLUTION OF SEDIMENT DISCHARGE BASED ON LIQUID FLOW RATES OF THE MEWOU RIVER IN THE MIFI BASIN

[1,4]Gouafo Casimir (Ph.D) ,

Fotso Victor University Institute of Technology, Civil Engineering Department, Laboratory of Industrial and Systems Engineering Environment (LISIE), University of Dschang Cameroon, , PO BOX 134 IUT FV BANDJOUN CAMEROUN

[1]Kamdjo Grégoire (Ph.D) ,
Fotso Victor University Institute of Technology, Civil Engineering Department, Laboratory of Industrial and Systems Engineering Environment (LISIE), University of Dschang Cameroon,

[2]Keyangue Tchouata Jules Hermann (Ph.D),
Department of Mine-Mineral Processing-Environment, University of Ngaoundere, Cameroon,

[3,4]Yerima Bernard Palmer Kfuban (Professor),
Department of soil Science, Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon, Email: bernardyerima@yahoo.com
[4]Laboratory for the Soil and Environment, Faculty Agronomy and Agricultural Sciences (FASA)

ABSTRACT: *The objective of this study is to evaluate and to model the evolution of sediment discharge depending on the liquid flow of the Mewou River in the catchment of the Mifi. The amount of exported soil was determined by oven drying of the water samples collected from the Mewou River at 105 °C. The MATLAB software has enabled us to simulate the evolution of sediment discharge based on liquid flow rates. The evolution of sediment discharge based on liquid flow rates obtained in this study is characterized by the polynomial model of equation nine degrees a correlation coefficient of 0.9999 and a determining coefficient of 0.9998:*

$$Q_s = a* Q_l^{9} + b* Q_l^{8} + c* Q_l^{7} + d* Q_l^{6} + e* Q_l^{5} + f* Q_l^{4} + g* Q_l^{3} + h* Q_l^{2} + i* Q_l + j$$

This equation is more representative than the power model « $Qs = a*Q_l^b$ » which has a correlation coefficient of 0.9891 and a determining coefficient of 0.9783 or the power model « $Qs = a*Q_l^b + b$ » which has a correlation coefficient of 0.9934 and a determining coefficient of 0.9868 developed by other authors.

KEYWORDS: sediment discharge, water discharge, model, function, simulate.

INTRODUCTION

Rainwater, charged with carbon dioxide and other elements through the atmosphere and the surface of the soil, dissolves part of their minerals and triggers a series of chemical phenomena, causing chemical weathering of rocks (Fournier, 1969). Thus, the dry rocky elements are fragmented, reduced to the size of sand, silt or clay.

Erosion is a process that tends to reduce the surface of continents the thickness of soil and rock, by physically pulling the solid particles that are exported suspended by surface runoff into rivers to reach the oceans and intra continental basins (Probst, 1992). Several authors see water erosion in the tropics from two angles: geological or normal erosion and accelerated erosion ((El-Swaify et *al*., 1982). As a general principle, human activity is the main cause of erosion, just as much as deforestation, agriculture, livestock and urbanization. This is the origin of the presence of solid particles in streams creating the solid flow.

This study is a quantitative assessment and modeling of sediment discharge based on liquid flow rates.

LITERATURE/THEORETICAL UNDERPINNING

Mathematical models generally consist of a set of variables chosen to represent the object studied and a set of mathematical relationships between these variables chosen to represent its function (Zug and Vazquez, 2010). The conceptual validity of an instrument is its capacity to produce a measure, which must agree with the theoretical links between the measured concepts (Martel et *al*., 2009). In other words, it is to collaborate the conceptual or theoretical significance of the measure. The conceptual validity of the models is done by calculating the correlation between the data obtained from the measurements and the model.

Each author characterizes the region or watershed studied, using the most representative and reliable model (Bouanani, 2005), that is, having a good correlation coefficient between the data collected and the model, taking into account errors in measurements, and any inaccuracies caused during the experiment or other conditions related to the phenomena studied, such as coherence between soil transport and precipitation, soil transport and erosion.

Quantitative assessment of the disaggregation of soils in watersheds can be carried out using two approaches. The first approach is to quantify erosion through models, involving morphological, climatic and hydrological parameters. The second approach is to estimate the quantities of suspended matter discharged by the watercourses at the outlet of the basin studied. Most erosion quantification measures are done on standard size plots (Wischmeier et *al*., 1971, Roose, 1967, Roose et *al*., 1998). Meanwhile, the study of suspended transfers at the watershed scale proves to be an effective tool for understanding and quantifying soil erosion processes.

Several models have been presented by different researchers, based on representative physical parameters (Albergel et *al*., 2001, 2003). Below are some of his models:

The annual flow of suspended solids exported from a watershed of Wood (1977) and Williams (1989), given by the formula As = $\sum_{j}^{N}(t_{j+1}-t_j)Q_jC_j$. The terms Cj, Qj, N and (tj+1 – tj) respectively correspond to the concentration measured at instant tj, to the liquid flow rate at instant tj, to the number of samples taken over the year in question, and to the time separating two consecutive levies.

ISSN 2055-6578(Print), ISSN 2055-6586(online)

The calculation of the suspended solid flow is based on the measurement of the liquid flow rate of the flow. The average solid flow of suspended sediment passing through an average flow section is calculated by the product of the average concentration of suspended sediment Cs by the average liquid flow rate Q_1 for a given period of time. This method was used in this work.

The concentration of suspended sediment Cs and the liquid flow rate (Q_1) generally evolve according to a power model (Etchanchu and Probst 1986, Walling and Webb 1981, Walling 1984, Wood 1977, Tavares 2010) Expressed with coefficients a and b by $Cs = a * Q_l^{b-1}$. Another empirical relationship, called the solid transport curve (Cambell and Bauder, 1940, Crawford, 1991) links the solid flow to the liquid flow along $Qs = a * Q_l^b$.

The parameters a and b are generally estimated, by linear regression of the variables, transformed into Log: $LogQs = Loga + b * LogQ_l$.

The catchment area of the South Mifi, coverings an area of 1640 km^2, is drained by four large rivers; We can distinguish the Mape to the north, a tributary of the Mbam; the Nkam to the south-west which, under the name of Wouri, flows into the sea at Douala and drains the south-western edge of the Bamileke plateau and the locality of Dschang; the Ndé in the south-east, a tributary of the Noun, which drains much of the mountainous region of western Cameroon, after having taken its source in Mount Oku (3070 m).

Geological studies show that the locality essentially comprises the formations of the basement, and the volcanic formations; covering most of the highlands of western Cameroon (Olivry, 1976). The formations of the base are mainly composed of calco-alkaline embedded gneisses. The basin of the South Mifi (study site) is composed of 77% of "basalt plateau", 20% of basement formations and 3% of alluvial and basanitoid trachytes. The soils of the western region come from the alteration of these rocks and are mainly red ferralitic soils, on basement materials or basalts of the plateau, or humifers on trachytes and mountain basalts. Several types of hydromorphic soils are observed, as well as poorly evolved soils, pyroclastic or ash-derived basalts.

METHODOLOGY

Field site and Sampling

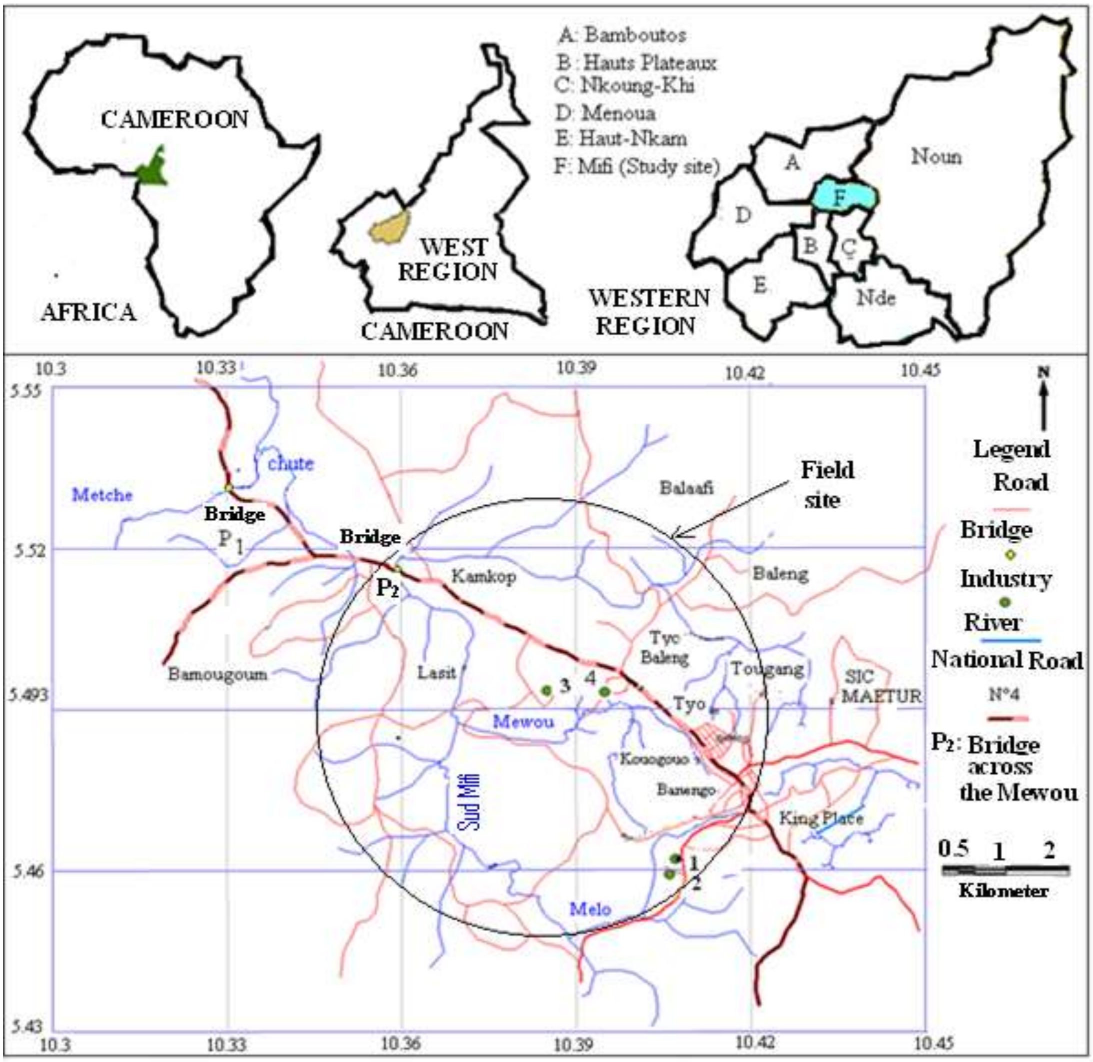
The station selected to determine the quantities of soil exported by the Mewou river (found in the South Mifi) is located at coordinates 5 ° 30'8 "N; 10 ° 22'7" E, Alt. 1279 m, on national road number 04 (Figure 1), designated P_2 in Figure 1.

According to Rodier et *al*., (2009) and MINEDD (2006), in order to have a representative sample of sediment concentration, the material must be buried in water so that the sample is not surfaced precisely in a place where water is not calm.

ISSN 2055-6578(Print), ISSN 2055-6586(online)

The samples were taken, once a week, over a 19 months of study period. A total of 76 samples were considered to determine the quantities of soil exported, in addition to 76 measurements of the flow of the Mewou river. The determination of the quantity of exported soil, was done in the Laboratory of Industrial and Environmental Engineering Systems (LISIE) of the University of Dschang.

Figure 1: Part of the hydrographic of southern Mifi showing the location of the bridge P_2 Mewou



Source: Made using, a GPS, from a background map of the region (2012)

Climate of the region

The climate in the studied area was relatively stable over the years. From the ombrothermal diagram according to Gaussen and Bagnouls (1952) (Figure 2), the studied area have two seasons: the rainy season from 15 March to 15 November and the dry season from 16 November to 14 March . The meteorological conditions of the region are represented by meteorological data from the weather station at Bafoussam-Bamougoum Airport (Appendix 1 and Appendix 2). This station is located close to

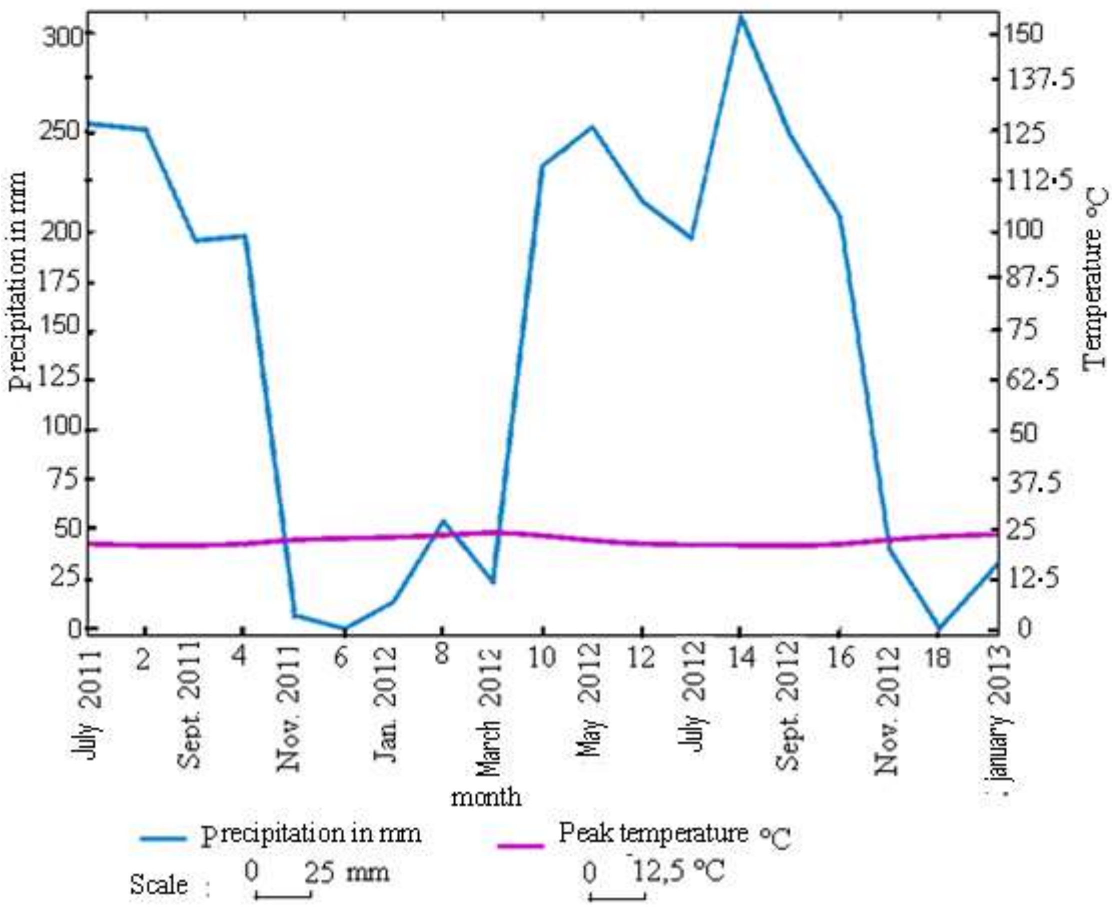
ISSN 2055-6578(Print), ISSN 2055-6586(online)

the studied area, and in the recruitment area (catchment area) of the waters of the Mewou river, which is one of the watercourses of the Mifi Sud catchment area. It is located between 5 ° 32'13 "N and 10 ° 21 '16" E at altitude 1325 m.

The annual rainfall over the passed 12 years (2002 to 2013, see Appendix 1) varied from a minimum of 1410.1 mm in 2011 to a maximum of 2026.2 mm in 2013. The maximum rainfall was 477.9 mm in July 2013 and the minimum rainfall was 0.0 mm in January 2007, 2010, February 2004, February 2007, 2008 and December 2003, 2005, 2007, 2009, 2010 and 2011.

From this meteorological data, the mean temperature in the dry season is 23.2 ° C. It was greater than the average temperature in the rainy season 21.86

Figure 2: Ombrothermic diagram according Gaussen and Bagnouls (1952), of Bafoussam and surroundings



Methods of experimentation

Assessment of water flow and exported soil

The flow rate Q_l in m^3/s was determined using a gauging float (Rodier et *al*. 2009, Bernard 1994) following the formula: $Q_l = 0.8*L*H*V$

Where L = useful width (flowable) in m, H = average water depth in m and V = maximum velocity (flow rate) of the water surface in m/s.

The amount of exported soil concentration (Cs), of the Mewou watercourse expressed in kg / l was determined by oven drying of the water samples collected from the Mewou River at 105 °C. The amount of soil exported (Qs) by water in g/s or in kg/s was determined from the water flow rate (Q_l) following the expression: Qs = Q_l * Cs
Where Cs is the weight of soil per liter of water exported (in g/l; g/m^3 or in Kg/m^3). For a period of time T, we had a soil loss (Q_T) from the expression:
Q_T = Qs*T.

RESULTS/FINDINGS

*Table 1 : Liquid flow rate of the Mewou river (l/s), soil exported by the Mewou river **(g/l,** kg/s and kg/month) from July 2011 to January 2013.*

Year	Month	Duration of the month in days	Liquid flow rate in (l/s)	exported soil (g/l)	exported soil (kg/s)	exported soil kg/month
2011	July	31	8 900	0.29	2.581	6 912 950
	August	31	32 711	0.26	2.079	5 568 394
	Sept.	30	8 350	0.1	0.752	1 949 184
	October	31	11 474	0.16	1.858	4 976 467
	Nov.	30	10 311	0.22	2.331	6 041 952
	Dec.	31	6 363	0.27	1.657	4 438 109
2012	Jan.	31	3 727	0.11	0.374	1 002 445
	Fév.	29	2 373	0.15	0.377	944 110
	March	31	2 151	0.1	0.208	556 357
	Apr.	30	5 372	0.98	7.746	20 078 669
	May	31	5 513	0.23	1.317	3 527 855
	Jun	30	9 037	0.26	2.796	7 247 232
	July	31	11 630	0.26	3.018	8 083 947
	August	31	12 786	0.3	2.928	7 842 623
	Sept.	30	13 831	0.23	3.158	8 184 266
	Oct.	31	16 326	0.332	5.407	14 483 716
	Nov.	30	12 598	0.14	1.764	4 571 562
	Dec.	31	7 543	0.09	0.679	1 818 285
2013	Jan.	31	5 953	0 .3	1.786	4 783 622

In the present study, the Pearson coefficient of correlation R and the determination coefficient R^2 were determined using Microsoft Office Excel (Microsoft, 2010) and the MATLAB software (Jerome, 2009). This software allowed us to develop a new-order polynomial model that better accounts for the relationship between the evolutions of solid flows as a function of long-term liquid flows according to the equation of the form:

$Q_s = a^* Q_l^{\,9} + b^* Q_l^{\,8} + c^* Q_l^{\,7} + d^* Q_l^{\,6} + e^* Q_l^{\,5} + f^* Q_l^{\,4} + g^* Q_l^{\,3} + h^* Q_l^{\,2} + i^* Q_l + j$

Where Qs represent the solid flow rate, Q_1 is the liquid flow rate, and the coefficients a, b, c, d, e, f, g, h, i and j vary, depending on the Qs values obtained during the study.

DISCUSSION

The data collected have been transformed into averages, and in some cases, presented in tabular form and curves. Table 1 summarizes liquid flows, solid flows and quantities of soil exported during the study period from July 2011 to January 2013.

The data in Table 1 made it possible to construct the curves of variation of the solid flow rates of the Mewou stream as a function of the liquid flow rates respectively, according to the power and polynomial models.

Figure 3a : Changes in solid discharge Qs kg/s of the Mewou watercourse based on liquid flow rate Q_l in m^3 /s (Power model $Qs = a^*Q_l^{\,b}+c$)

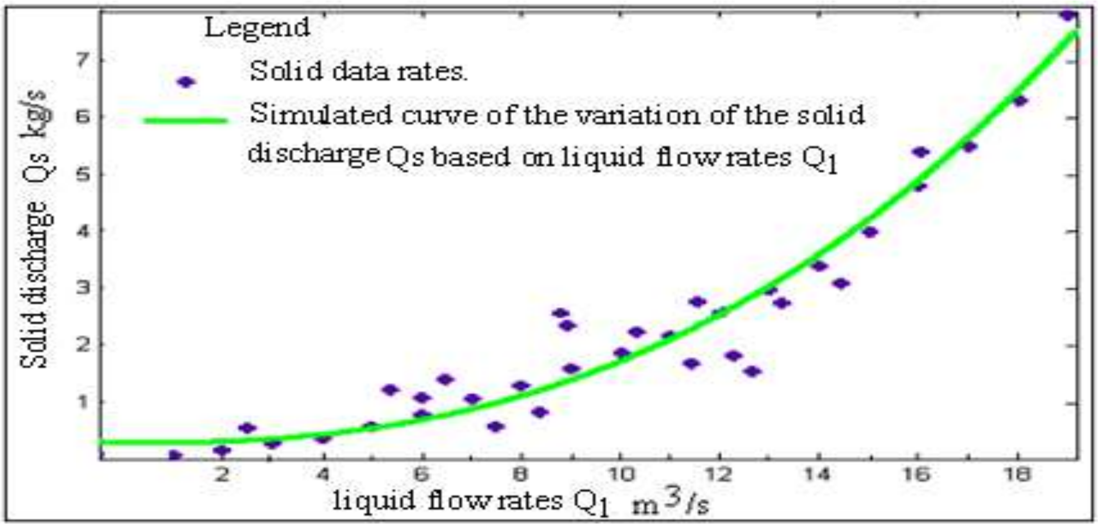


Figure 3b : Changes in solid discharge Qs kg/s of the Mewou watercourse based on liquid flow rate Q_l in m^3 /s (Power model $Qs = a^*Q_l^{\,b}$)

ISSN 2055-6578(Print), ISSN 2055-6586(online)

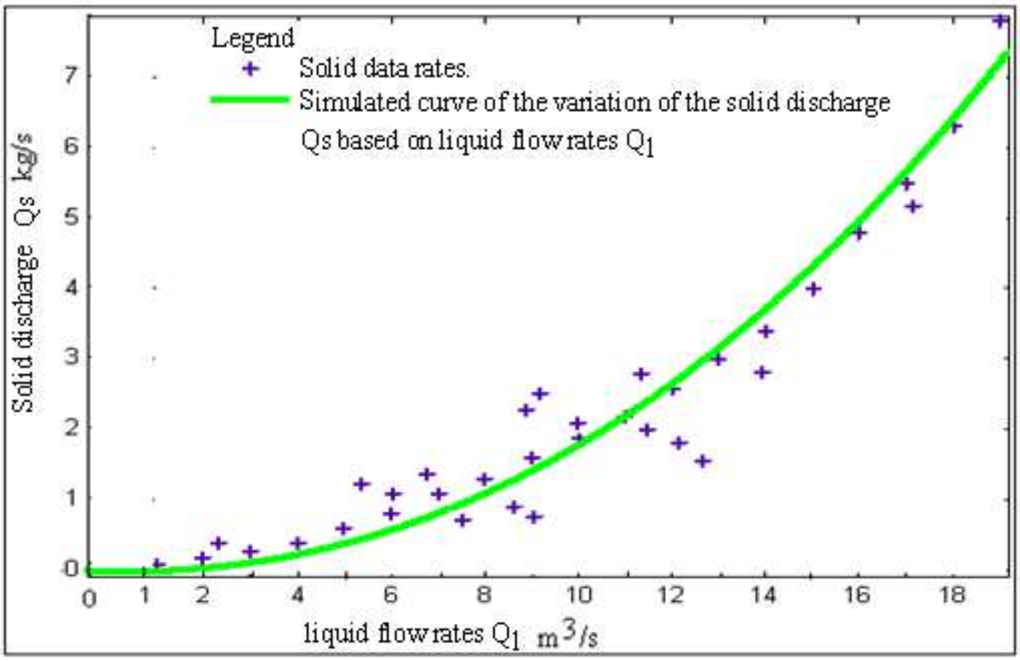
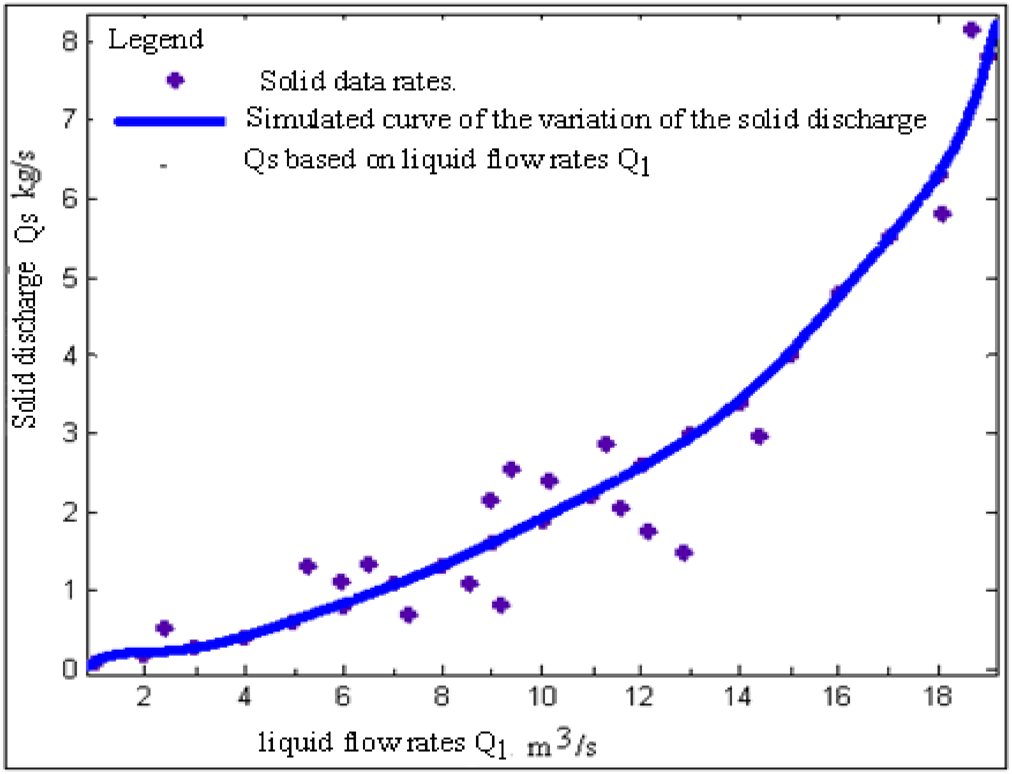


Figure 3c : Changes in solid discharge Qs kg/s of the Mewou watercourse based on liquid flow rate in m^3 /s (polynomial model $Q_s = a^* Q_l{}^9 + b^* Q_l{}^8 + c^* Q_l{}^7 + d^* Q_l{}^6 + e^* Q_l{}^5 + f^* Q_l{}^4 + g^* Q_l{}^3 + h^* Q_l{}^2 + i^* Q_l + j$)



The analysis of the graphs indicated that the solid flows grow in the same direction, as the liquid flows. High liquid flow rates (> 12 m^3 / s) resulted in strong solid transport (Figure 3a; Figure 3b; Figure 3c). This demonstrated that solid transport which

ISSN 2055-6578(Print), ISSN 2055-6586(online)

required an energy source, was closely linked to flow without genuine proportionality (Ghenim et *al*., 2007).

Coefficients a, b, c, d, e, f, g, h, i and j varied according to the values of Qs obtained during the study, making it possible to write the equations of the respective power and polynomial models as:

$Q_s = 0.00451*Q_l^{2.497} + 0.3234$; $Q_s = 0.01186*Q_l^{2,177}$ and $Qs = 0.00000002609*Q_l^9 - 0.000002242*Q_l^8 + 0.00008141*Q_l^7 - 0.001628*Q_l^6 + 0.01961*Q_l^5 - 0.1459*Q_l^4 + 0.6605*Q_l^3 - 1.697*Q_l^2 + 2.264*Q_l - 1.003$.

Table 2 summarizes the correlation coefficients R and determination coefficient R^2, with respect to the points, passing at best in the cloud of points harvested.

Table 2:The correlation coefficients R and determination coefficient R^2, with respect to the points, passing at best in the cloud of points harvested.

Models		Correlation coefficient (R)	Determination coefficient (R^2)
Power models	$Q_s = 0.00451*Q_l^{2.497} + 0.3234$	0.9934	0.9868
Power models	$Q_s = 0.01186*Q_l^{2.177}$	0.9891	0.9783
Polynomial models	$Qs = 0.00000002609*Q_l^9 - 0.000002242*Q_l^8 + 0.00008141*Q_l^7 - 0.001628*Q_l^6 + 0.01961*Q_l^5 - 0.1459*Q_l^4 + 0.6605*Q_l^3 - 1.697*Q_l^2 + 2.264*Q_l - 1.003$.	0.9999	0.9998

The three models have significant coefficients of correlations (Legates and McCabe, 1999, Donner and Eliasziw, 1987), with values greater than 0.91. The three models have small deviations, 1.08% between Figure 3c and Figure 3b and 0.65% between Figure 3c and Figure 3a.

IMPLICATION OF THE MODEL TO RESEARCH AND PRACTICE

-Prediction of silting of dams and harbors for dredging;
-Prediction of the quantity of solid particles as a function of the flow rate for the treatment of drinking water.

CONCLUSION

The power models "$Qs = a * Q_l^b$" or "$Qs = a * Q_l^b + b$" developed by Bouanani (2005); BenKhaled and Rimini (2003); Probst and Bazerbachi (1986) do not represent the phenomenon well. The polynomial model of degree nine "$Q_s = a* Q_l^9 + b* Q_l^8 + c* Q_l^7 + d* Q_l^6 + e* Q_l^5 + f* Q_l^4 + g* Q_l^3 + h* Q_l^2 + i* Q_l + j$" , obtained in this study, using MATLAB software, is recommended for future predictions, compared to

ISSN 2055-6578(Print), ISSN 2055-6586(online)

previous models, because it is more precise, as indicated by the correlation coefficient, and the coefficient of determination.

The choice of the model, depending on the precision, which we want to give to the result, the polynomial model, can better predict the solid flow, as a function of the liquid flow. It is more representative than power models as indicated by the correlation coefficient.

FUTURE RESEARCH

• To characterize the sub-basin, which has as an outlet the Metche, stream and the other sub-basins of the South Mifi;
• The use of other methods and models, particularly those based on algorithms and statistical adjustments.

REFERENCES

BenKhaled, A. and Rimini, B., 2003. Analysis of the power relationship: solid flow rate based liquid Flow rate throughout the Oued Wahran catchment (Algeria). Rev. Sci. water 16/3(2003) 333-356.

Bouanani, A., 2005. Hydrology, Transportation Solid and Modelling Study of some sub basins of Tafna (NW- Algeria). Doctoral thesis. University Abou Belkaïd Tlemcen.

Cambell, F.B. et Bauder, H., 1940. A rating-curve methode for determining silt-discharge of stream, EOS Trans. Am. Geophys. Union, 21, 603-607.

Crawford, C.G., 1991. Estimatin of suspended –sediment rating curves and mean suspended-sediment load, journal of hydrology, 129, 331-348.

Donner, A and Eliasziw, M., 1987. Sample size requirements for reliability studies. Stat Med. 1987; 6: 441-448.

El-Swaify, S. A., Dangler, E. W. et Armstrong, C. L., 1982. Soil Erosion by Water in the Tropics. 630 US ISSN 0271-9916. Research Extension Series 024, p. 184.

Etchanchu, D. and Probst, J.L., 1986. Erosion and transportation of suspended solids in a watershed in agricultural area. method of measuring the surface runoff, charge and two components of the sediment transport in rivers. C. R. Acad. Sci. Paris, 302, série II, n° 17 1063-1067.

Fournier, F., 1969. Water erosion and climate. Technical Information Bulletin of Meteorology and Agriculture. nº 237. Pp.111-115.

Ghenim, A, Seddini, A. and Terfous, A., 2007. Production and export of suspended sediment during flood events. Case of Wadi mouilah catchment. Larhyss Journal, ISSN 1112-3680, n° 06, December 2007, pp. 35-44.

Jerome B. 2009. MATLAB R2009b « Matrix Laboratory ». Society Mathworks.

Legates, D. R. and McCabe, G.J., 1999. Evaluating the use of “goodness-of-fit” measures in hydrologic and hydroclimatic model validation. Water Resources Research 35: doi: 10. 1029/1998WR900018. Issn: 0043-1397.Florida Avenue N.W. Washington, D.C.

Microsoft O., 2010. Microsoft Office 2010 Home and Business. PC License English.

MINEDD, 2006. The Sample collection in rivers: Sampling techniques for liquid analysis. Technical Guide November 2006. Water Agency Loire- Britain Avenue Buffon.132p.

Olivry, J. C., *1976.* hydrological regimes in Bamileke region, Cameroon. Cah. ORSTOM, ser. Hydrol. ml. XIII, no 1. P. 37-71.

Probst, J.L., 1992. Geochemistry and hydrology of continental erosion. Mechanisms, current global balance etfluctuations in the last 500 million years. Geological Sciences. Memory. N° 94. ISSN 0302 – 2684, pp.60.

Probst, J. L. and Amiotte S. P., 1992. Fluvial suspended sediment transport and mechanical erosion in the Maghreb. Hydrol. Sci. J. 37(6), 621-637.

Probst, J.L. and Bazerbachi, A., 1986. Transport in solution and in suspension by the upper Garonne. Sci. Geol. Bull., 39, 1, 79-98.

Rodier J, Legube B, Merlet N, Coll. 2009. Analysis of the water . 9e édition Dunod, Paris, France. P .1579.

Roose, E., 1967. Ten years of measuring runoff and erosion at Sefa in Senegal. Agron. Trop., 22,2 : 123-152.

Roose, E., De Noni, G. and Lamachère, J-M., 1998. Erosion to ORSTOM: 40 years of multidisciplinary research.. Res. Ero. Orstom, Montpellier, France. 66 p.

Tavares, J.D.P., 2010. Soil erosion, Cape Verde: `process and quantification across three Watershed of the island of Santiago. Earth Sciences. Bourgogne University, 2010. French.

Walling, D. E., 1984. The sediment yields of African rivers. IAHS Publ., Harare Symp. 144, 265-283Seltzer, P., 1946 - le climat de l'Algérie. Univ. Alger. Inst. Météo et Phys du Globe, Carbonnel. 219 p., 2 cartes.

Walling, D. E. et Webb, B. W., 1981. The reliability of suspended load data. In: Erosion and Sediment transport measurement. IAHS Publ., 133, 177-194.

Williams, G. P., 1989. Sediment concentration versus water discharge during single hydrologic events in rivers. J. Hydrol. 111, 89–106.

Wischmeier, W. H., Johnson, C.B. et Cross, B.V., 1971. A soil erodibility monograph for farm lands and construction sites. journal of soil and water. Vol. 265.

Wood, P.A., 1977. Controls of variation in suspended sediment concentration in river Rother, West Sussex, England. Sedimentology 24: 437-445.

Zug, M., Vazquez, J., 2010. Modelling of sanitation. Concepts, approaches and steps. During the 3rd year. ANJOU ENGEES SEARCH.

Appendix 1: Rainfall (mm / month) in Bafoussam-Bamougoum from January 2002 to December 2013

Month	Jan.	Feb.	March	April l	May	June	July	August	Sept.	Oct.	Nov.	Dec.	
years													Tota
2002	4.0	16.	123.1	147	128.	280.	315.	253.	254.	247.		18.	1588
2003	1.1		39.2	128	123.	232.	222.	276.	234.	267.			1580
2004	1.2		40.3	266		256.	287.	244.	195.	323.	141.	17.	1867
2005	52.9	83.	76.7		238.	177.	175.	309.	299.	230.			1760
2006	8.1	75.	149.5		298.	209.	246.	310.	254.	153.			1836
2007	0.0		29.6	262	176.	221.	273.	236.	194.	280.	143.		1817
2008	5.6		106.5	207	171.	201.	179.	239.	290.	152.			1561
2009	2.7	14.	42.2		201.	170.	268.	383.	223.	260.			1665
2010	0.0	48.	87.2		215.	249.	161.		302.	228.			1555
2011	9.8	32.	80.9	105	197.		253.	251.	195.	197.			1410
2012	13.7	54.	23.6	233	252.	215.	196.	308.	247.	207.			1791
2013	27.9	15.	119.7	181	187.	176.	477.	210.	279.	236.		15.	2026

Source: Weather Station Bafoussam-Bamougoum Airport (5°32'13"N, 10° 21' 16" E, Alt.1325

Appendix 2: average monthly temperature of daily temperature of the station Meteorological from the airport Bafoussam-Bamougoum period 2002-2013 in ° C

Mont **Year**	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
2002	23.	24.	24.8	24.2	23.	22.	22.	21.3	21.4	21.	23.	22.
2003	23.	24.	24.9	23.1	22.	21.	20.	21.0	20.7	21.	22.	22.
2004	23.	24.	24.7	22.7	23.	21.	20.	22.7	21.1	21.	22.	22.
2005	22.	24.	23.9	24.0	21.	21.	20.	20.6	21.0	21.	21.	21.
2006	22.	23.	23.1	22.7	22.	19.	21.	20.9	20.9	21.	22.	22.
2007	22.	24.	24.7	25.6	22.	21.	20.	20.6	20.9	21.	21.	22.
2008	22.	23.	23.5	20.1	22.	21.	20.	20.7	20.2	21.	22.	22.
2009	23.	24.	24.8	22.9	22.	21.	21.	20.8	21.0	21.	22.	23.
2010	23.	23.	24.4	23.9	23.	21.	21.	21.1	20.2	21.	22.	23.
2011	22.	23.	24.1	23.6	22.	21.	21.	21.0	21.1	21.	22.	22.
2012	23.	23.	24.6	23.4	22.	21.	21.	21.2	20.9	21.	22.	23.
2013	23.	24.	23.5	23.3	23.	22.	21.	21.4	21.4	21.	22.	21.

Source: Weather Station Bafoussam-Bamougoum Airport (5°32’13”N, 10° 21’ 16” E,

ISSN 2055-6578(Print), ISSN 2055-6586(online)