ORIGINALE ARTICLE

QUANTIFICATION AND SEASONAL ANALYSIS OF SUSPENDED SEDIMENT TRANSPORT IN THE DJIBI RIVER BASIN, ABIDJAN, CÔTE D'IVOIRE

| Yao Lucien Kouassi [1*] | Ehouman Serge Koffi [1] | Koffi Jean Thierry [1] | Koffi [1] | Fernand Kouamé [2] | Amidou Dao [1] | Djbril Dabissi Noufé [1] | Bamory Kamagate [1] | Seydou Diallo [1] | and | Droh Lanciné Goné [1] |

[1.] Laboratory of Geosciences and Environment | University Nangui Abrogoua | Unit or Laboratory | Abidjan | Ivory Coast |
[2.]Research and Digital Expertise Unit | Université Félix Houphouët Boigny |

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ABSTRACT

Introduction: The expansion of the District is contributing to the degradation of the vegetation cover within the District and its periphery, giving way to built-up areas and increasingly sealed areas. It can therefore be subject to flooding risks, or it can encourage huge run-offs and participate in the process of water erosion. **Objective**: The objective of the present study is to analyze data on the concentration of suspended sediments measured at the Djibi station, which is a tributary of the Aghien lagoon, to highlight the relationships linking the concentration (or solid flow) of suspended sediments to the liquid flow and to quantify the seasonal, monthly, daily and annual variation in solid flow. **Method**: One widely used method is the solid transport estimation curve, which generally relates suspended sediment concentration to liquid flow. **Results**: The results of the suspended solids analysis allowed the identification of the different seasonal inputs. However, the annual solid inputs are estimated at 348.3.103 t/year with a specific degradation of 4944.45 t/km²/year at the Djibi from 2015 to 2017. **Conclusion**: This study has shown that the Djibi River carries a huge amount of material flow to the Aghien Lagoon.

Keywords: *Abidjan District, solid transport, solid flow, sediment, suspended matter.*

1. INTRODUCTION

The drinking water supply of the populations of the autonomous district of Abidjan is ensured by the Continental Terminal water table [1]. Over the last few decades, this resource has been threatened by the accelerated expansion of the District of Abidjan [2]. This expansion of the District is also contributing to the degradation of the vegetation cover within the District and its periphery, giving way to built-up areas and increasingly waterproofed zones. The rate of urbanization resulting from this expansion has clearly increased with the appearance of several urban centers to the detriment of natural spaces and landscapes [3]. Thus, the demographic growth of the Autonomous District of Abidjan with a population estimated at 6,321,017 inhabitants [4] contributes to the destruction of biodiversity, and also contributes to the qualitative and quantitative degradation of both surface and groundwater [5,6]. Moreover, tangible signs of chemical and biological pollution, particularly nitrates, have been recorded in recent years in the Plateau, Adjamé and Abobo districts [7,8,9].

This led to the abandonment of some boreholes with nitrate levels above 50 mg/L [6], thus creating a deficit in drinking water supply. In order to strengthen the water supply capacity in the Autonomous District of Abidjan, the Ivorian government has turned to the exploitation of the Bonoua aquifer [10], the Mé river and the Aghien lagoon, where a water treatment plant is under construction. However, the Aghien lagoon, whose catchment area is located on the outskirts of the Autonomous District of Abidjan, is suffering from the full force of rampant urbanization, as it is home to the municipality of Abobo with a population of 1,340,083 inhabitants [4]. However, the Djibi river basin is becoming more and more impermeable and can therefore be subject to flooding risks or even favor huge run-offs and participatein the process of water erosion. The effects of runoff intensify when the soil is bare. Water erosion of soil is the detachment, transport and deposition of soil particles in depressions where water velocity is low. Some suspended solids can settle to the bottom of a watercourse as sediment and subsequently contribute to siltation and/or silting of water reservoirs. This study aims to understand the impact of sediment flows on the Aghien Lagoon. Methods for estimatingthe sediment load exist. One of the methods, which is widely used, is the solid transport estimation curve, which generally relates the concentration of suspended sediments to the liquid flow. The objective of the present study is to quantify the seasonal, monthly and annual variation in surface degradation of water erosion.

2. MATERIALS AND METHODS

2.1 Equipment

2.1.1 Geographical location: The Djibi basin has an area of 78 km². This basin is highly urbanized, including the most populated districts of the Abobo commune [1]. The commune of Abobo is one of the 13 communes making up the district of Abidjan. It is locatedin the north of the Abidjan agglomeration, about ten kilometers from the city center.

Abobo has been administered asa full-fledged commune since 1980, in accordance with Law No. 80-1182 of 17 October 1980 on municipal organization.The municipal territory of Abobo covers an area of 7,800 hectares. It is a vast plateau bordered by talwegs covering nearly 2,460 hectares and representing 31% of its area. This relief is marked by basins whose diameter varies from 100 to 500 meters. The maximum altitude is approximately 125 m. The climate of the municipality of Abobo is tropical andhumid with 2,200 mm of rainfall.

The geology of the region is marked by a sedimentary basin, consisting of sedimentary volcanic rocks. The outcropping sedimentary formations are attributed to the Quaternary and Tertiary periods. The tertiary formations are made up of coarse sands, bariolated clays, and iron ore-bearing sandstones of the low plateaux. The sedimentary formations of Quaternary age are made up of sands, gravelly sands, muds or clays, muddy sands and sandy or silty muds. The Djibi basin is entirely within the sedimentary basin [11,1].

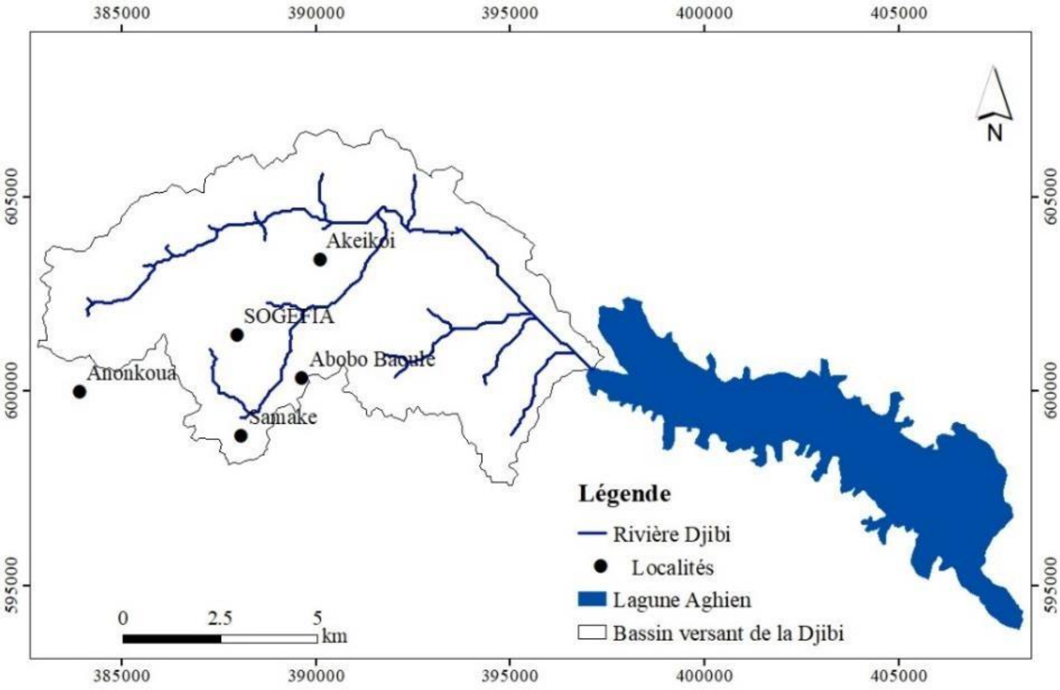

Figure 1: Location of the study area.

The sampling site is located close to the Aghien lagoon, all suspended solids from the Djibi River catchment were measured there (Figure 2).

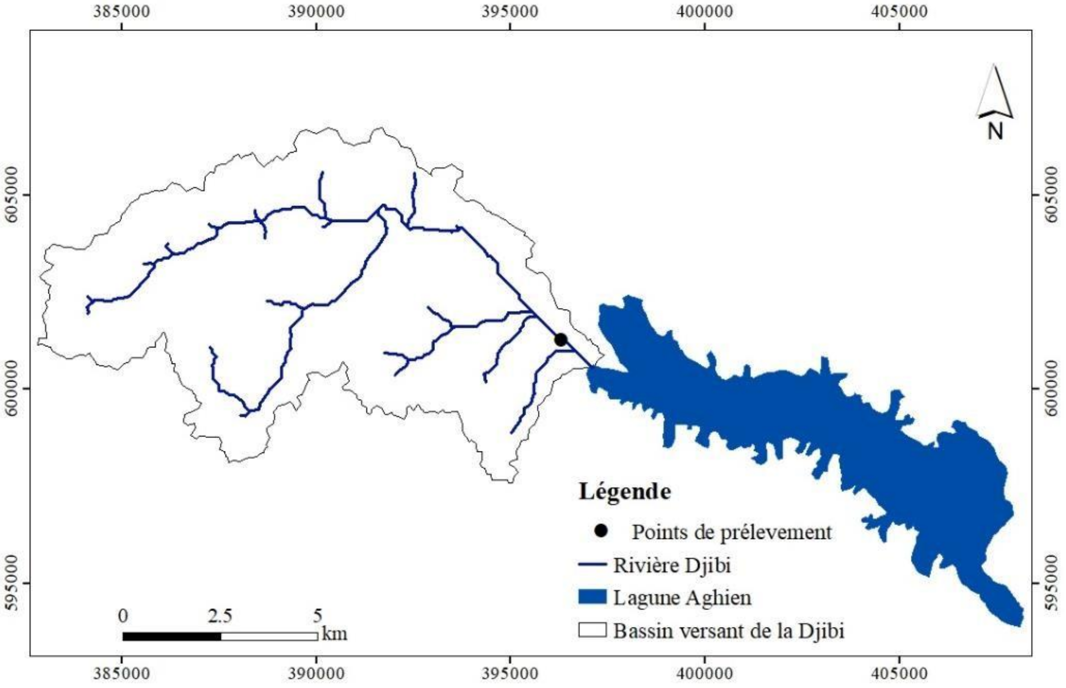

Figure 2: Sampling site.

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Samples were taken throughout the study period during low and high water in the Djibi River. These are spot samples(Figure 3).

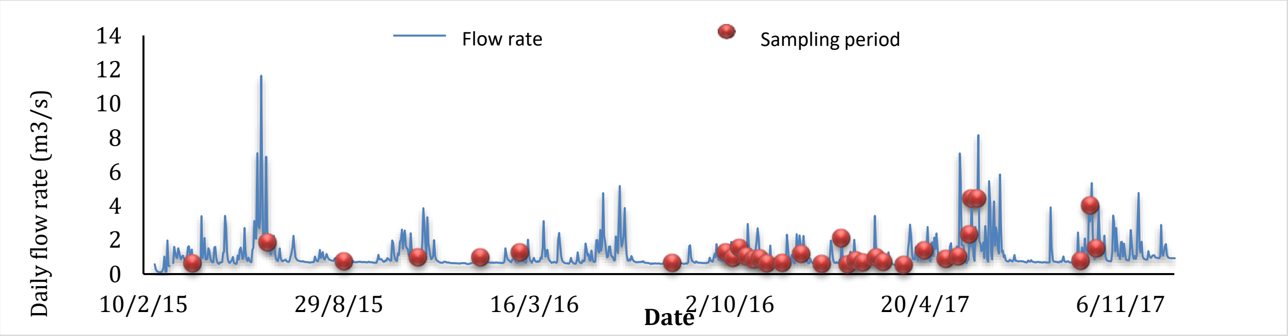

Figure 3: The figure illustrates the sample distribution based on flow rate and sampling period.

2.2 Method

In the laboratory, the filter (0.45µm) is dried for 2 hours in an oven at 105°C. After drying, the filter is weighed. The empty mass is noted M_1 . A volume V of water was taken from the sample, generally between 100 and 500 ml. This volume was filtered onto the previously dried filter (dry weight M_1 in mg). The filter containing the filtrate was then dried for 2 hours at 105°C in an oven. After drying, the filter is weighed again (weight M_2 in mg). The concentration C is then expressed in g /l according to equation (1):

$$C_s = \frac{M_2 - M_1}{V} \quad (1)$$

M_1 : initial mass of the filter in (mg),
M_2 = mass of the filter after filtration in mg,
V= volume filtered (L),
Cs = material concentration (mg/L),

The filter paper used is Whatman type with a diameter of 0.45 µm and the TSS measurement protocol is as shown in Figure 4:

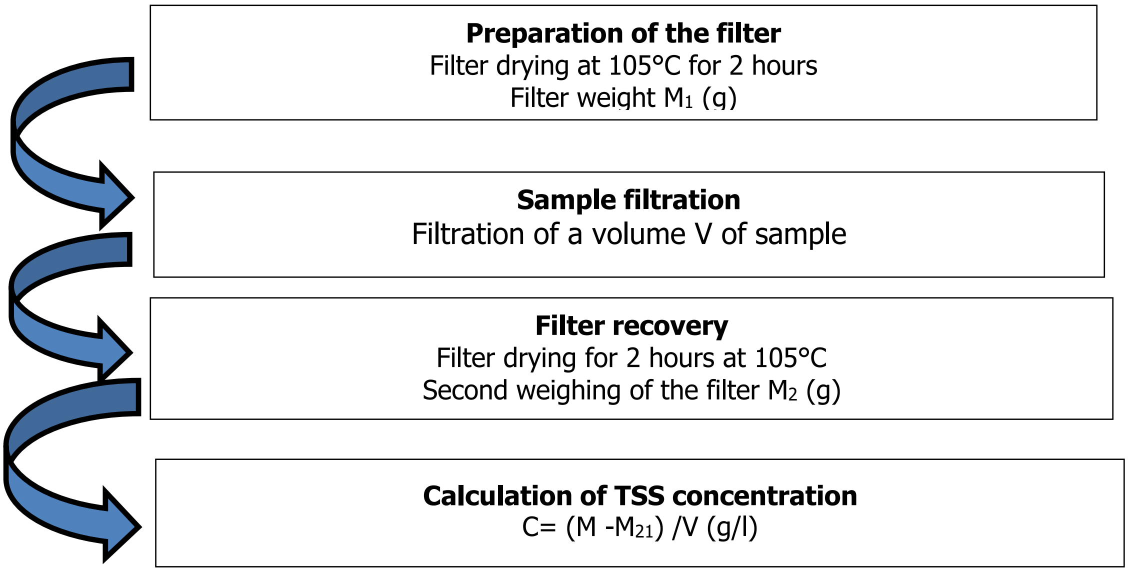

Figure 4: Suspended Solids (SS) measurement protocol.

2.2.1 Quantification of suspended sediment inputs

2.2.1.1 Solid transport curve

The statistical treatment of the liquid flow and the TSS concentration consists in finding a regressive model (Qs= f(Ql)), in order to achieve a satisfactory homogenization of the data and a quantification of the specific degradation of the studied stations. Regressive statistical methods were used to reconstruct the database of TSS concentrations. The suspended sedimentconcentration (C) and the liquid flow (Q) evolve according to a power model. Furthermore, a relationship was proposedby [12] and commonly known as the solid transport curve [13,14,15]. The parameter (a) reflects the sensitivity toerosion of the catchment and (b) (equation 2) is related to the erosive capacity of the river as well as to the increase in sediment availability as a function of flow [16,17,18,19,20].

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$$Q_s = aQ_l^{\,b} \tag{2}$$

Qs: solid flow (m^3 /s),
Ql: liquid flow (m^3 /s),
a and b: parameter.

2.2.1.2 Sediment flows

To quantify the flows (Fs), we proceed as if the concentration and the flow rate did not vary over a period of time equal to the time interval adopted, or more precisely to the sum of the two half-intervals preceding and following the sampling considered. Sediment fluxes will be expressed in t/days, concentrations in kg/m^3 , and daily flow in (m^3 /day). The sediment flux formula is as follows [21,22,19,20] equation (3):

$$F_S(tonnes/jour) = C_S * Q_l * 86,4 \tag{3}$$

2.2.1.3 Specific sediment flux or degradation

To determine the specific degradation, data from measurements of suspended solids flows in the main rivers of the three basins considered will be used. The specific degradation is the ratio of the solid flow to the surface area of the catchment according to equation 4 [19,20,23,24].

$$Q_{ss} = \frac{Q_s}{A} \tag{4}$$

Qss: specific solid flow t/km²/year,
A: catchment area km².

3. RESULTS

3.1 Catchment sediment flow dynamics

The results obtained show that the solid flow (Qs) is positively correlated with the liquid flow (Ql). These relationships were quantified by fitting a power model to the data (Qs/Ql) (Figure 5). This model gives the best results in terms of regression, regardless of the season. The correlations obtained are all significant and above 80%. However, the correlation is less significant in the early season on the Djibi (0.79). Moreover, the complete series of catchment areas give correlations above 80%.

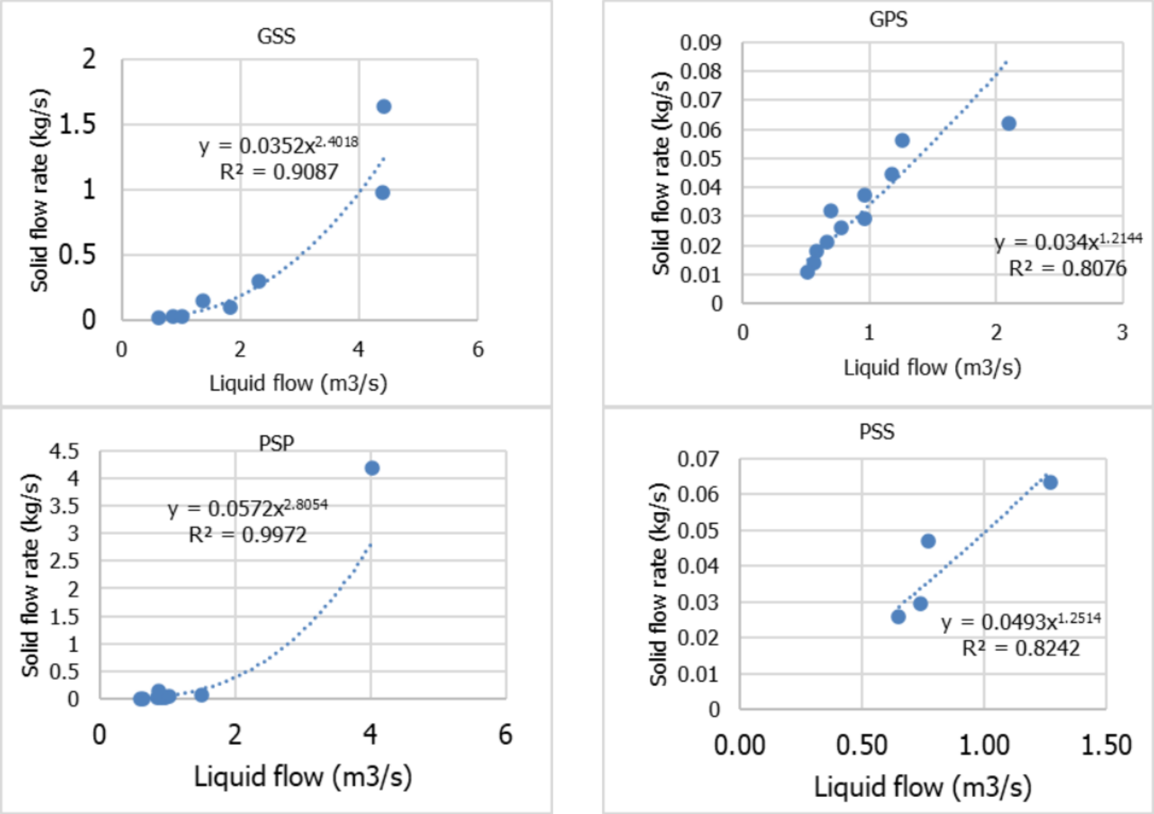

Figure 5: Solid and liquid flow modelling with trend curve for different seasons**.** (**GSS**: Great Dry Season, **GSP**: Great Rainy Season, **PSP**: Little Rainy Season, **PSS**: Great Dry Season, **Qs**: solid flow, **Ql**:liquid flow).

3.2 Seasonal and monthly variation of liquid and solid inputs

3.2.1 Seasonal variation of liquid and solid inputs to the Djibi

In order to better understand the phenomenon of erosion and solid transport, we have seen that it would be relevant to analyze the seasonal distribution of flows and suspended solid inputs in the basins. At Djibi the same trend is observed. The graphs reflect the seasons: solid and liquid inputs are low during the dry season, with very low values. The amplitudes of the inputs increase during the rains and we thus have a sawtooth evolution. The aggressiveness of the rainfall and the geology of the soil largely favor the phenomenon of erosion in the basins. Thus, in the years 2015 and 2017 a significant amount of solid input was detected for sizes of 2.83 10^3 t and 2.63 10^3 t belonging to the big and small rainy season (Figure 15). On the other hand, the only small wet season of 2017 outperforms the large rainy seasons with a quantity of suspended matter of 2.96 10^3 t (Table 1).

Table 1: Seasonal liquid and solid inputs to the Djibi station.

Station	Year	Balance	GRS	GDS	SDS	SRS	Total
Djibi	2015	Liquid imput (Hm^3)	4.55	14.68	4.21	6.96	30.40
		Solid imput (10^3t)	0.15	2.83	0.20	1.21	4.39
	2016	Liquid imput (Hm^3)	9.31	11.48	4.18	5.64	30.61
		Solid imput (10^3t)	0.28	0.91	0.20	0.63	2.02
	2017	Liquid imput (Hm^3)	7.96	16.48	4.58	8.87	37.89
		Solid imput (10^3t)	0.24	2.62	0.23	2.96	6.04

The analysis of figure 6 shows that the long and short rainy seasons are distinguished by their strong liquid inputs, generating a significant flow of suspended solids. Thus, the liquid input to the outlet fluctuates constantly from one year to the next and from one season to the next, with the highest proportions occurring in the long rainy season, where liquid transport is considerable: 48% in 2015, 38% in 2016 and 44% in 2017. In this season the rainfall is high and reaches enormous quantities. These proportions reflect a very strong temporal disparity, both on a seasonal and annual scale. Indeed, more than 70% of the liquid transport during 2015 and 2017 was carried during the rainy seasons.These flows conveyed nearly 90% of the solid inputs. Except for 2016 when liquid exports could not exceed 60% and only 70% of the suspended matter flows were moved. Conversely, the minimum percentages are observed during theshort dry season: 14% in the first year and the second and 12% in the third year. Over the period studied, the short dry season represents the months during which the exports of suspended matter are the lowest, with less than 20%.

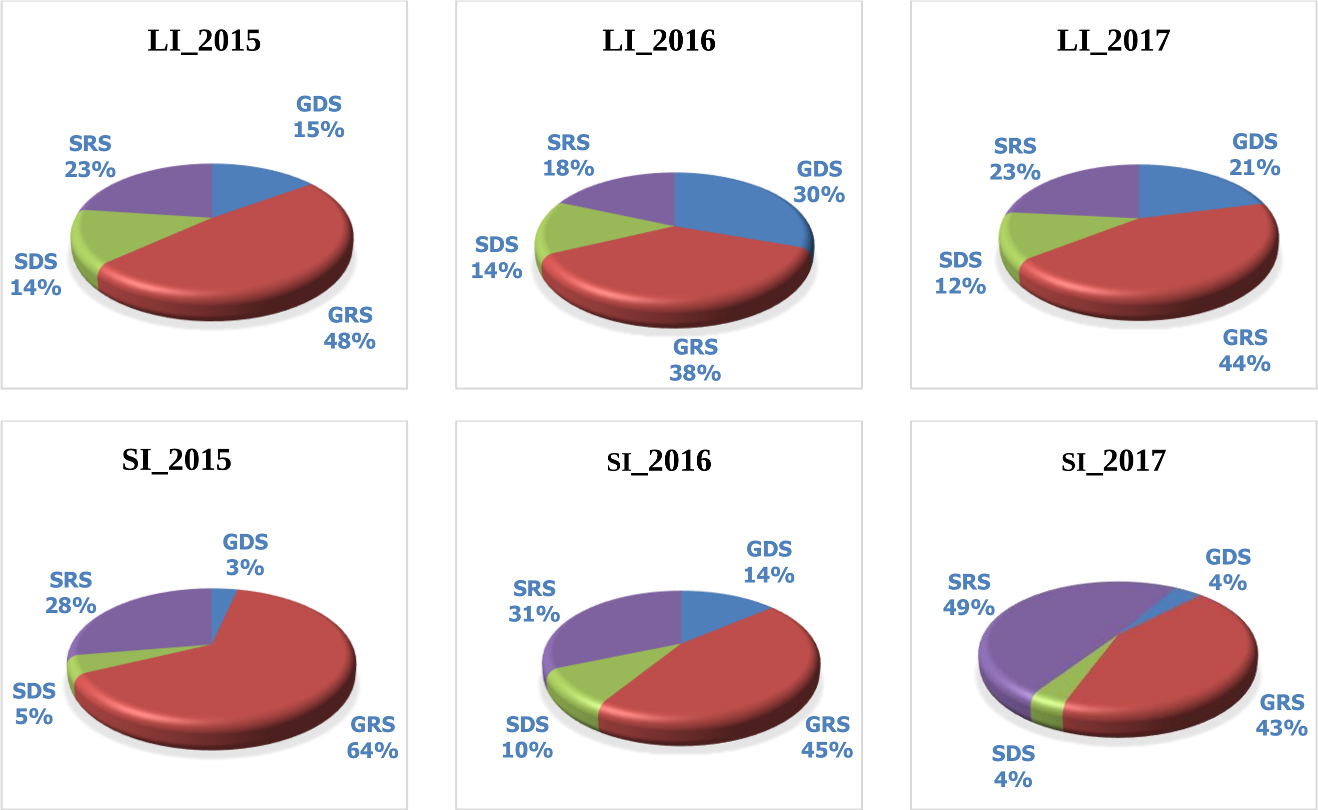

Figure 6: Seasonal percentage contribution of liquid and solid inputs in the Djibi sub-catchment.

3.2.2 Monthly variation at Djibi

The variations in monthly liquid inputs and the resulting suspended solids loads give an insight into the overall trend in the catchment's susceptibility to sediment production. The inputs follow a bimodal regime, resulting in two maxima, one in the main rainy season and the other in the short rainy season. In the Djibi basin, the monthly and spatial variationin erosive action is noticeable from one month to the next and over the three years of measurements. The most active months for erosion resulting from torrential rains or heavy downpours occur exclusively in June, the epicenter of the long rainy season, and these rains appear in October and sometimes in November for the short rainy season. The resulting runoff breaks up soil particles, putting them into solution, and carries them on its journey.

In 2015, the months of June and November alone accounted for 77.02% of the total solid input of 4.4 10^3 t, for a flow of 36.68% over 30.4 Hm^3 ; the contribution of the month of November is 22.72% for a net input of 0.9 10^3 t, while that of June the flow of sediment reaches its maximum with a contribution of 54.30% and a transport of 2.38 10^3 t. The total solid input for the remaining months of the year is modest and corresponds to 22.98%, which corresponds to a quantity of suspended matter of 1.01 10 t.$^{3\cdot}$

In 2016, the drop in rainfall had an immediate impact on the flow, considerably reducing the transport of suspended solids. The months of May, June and October therefore provided 62.84% of the total annual solid load (2.02 Mt), equivalent to a liquid input of 35.86%, i.e. an equivalent of 10.98 Hm^3 for a total of 30.61 Hm^3 . The solid load is distributed between the months as follows: May appropriates 0.33 10^3 t, i.e. a rate of 16.44% of the loads, June totals 22.24%, which represents a contribution of 0.45 10^3 t, and October drains a quantity of 0.49 10^3 t, equal to a proportion of 24.25%. The maximum value observed is attributed to October. The 37.16% is distributed among the other 9 months, which represent an input of 0.75 10 t^3.

In 2017, the June and October solid inputs alone accounted for 54.77% of the total (6.07 10^3 t) of the displaced material flow or a load of 3.33 Mt. This input was driven by a volume of over 10.73 Hm^3 of the total liquid flow of 39.14 Hm^3 . The month of June carried a load of 1.32 10^3 t equivalent to a rate of 21.74 % and October belonging to the short rainy season carried a stream of 2.01 10^3 t. The transport of solids related to these months was possible because the quantities of water recorded are huge, in June the flow volume of 5.72 Hm^3 and in October 5.01 Hm^3 was collected. The contributions of the remaining liquid and material flows are attributed to the 10 months (Figure 7).

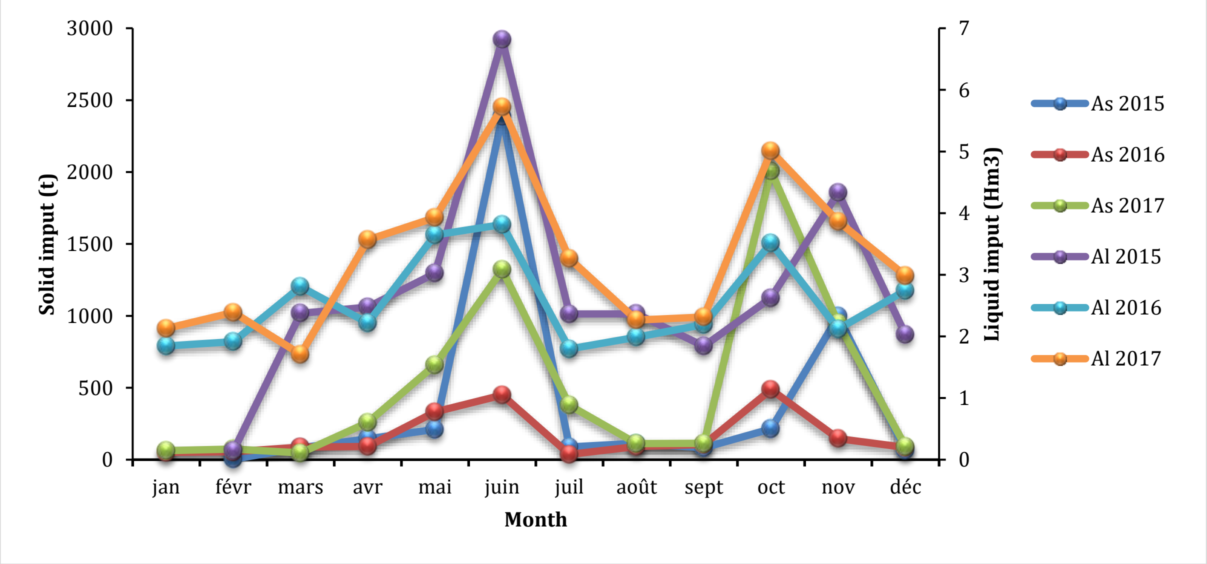

Figure 7: Monthly variation in liquid and solid inputs to the Djibi River.

3.2.3 Monthly variation of solid inputs to the Djibi

Variations in liquid inputs and suspended solids loads provide an overview of the sediments produced by the tributaries of the Aghien Lagoon. The inputs follow a bimodal regime, one in the long rainy season and the other in the short rainy season. In general, the monthly variations of the solid transport of the tributaries closely follow those of the flow. The complete series were used for the calculation of the monthly variation of the suspended solids input in each of the catchment areas. In the Djibi basin, the monthly variation in erosive action is noticeable from one month to the next and over the three years of measurements (Table 2).

In 2015, the months of June and November transported more than 77.88% of the total solid input which is 123.82.10^3 t, for a flow of 36.68% on 30.4 10^3 m^3 . June recorded the highest value of 71.43.10^3 t, which is 57.69% of the annual solid load. November's contribution in solid input is 16.33.10^3 t, or 13.19% of the annual total. For a balance input of, while that of June the sediment flow reaches its maximum with a contribution of 54.30% and a transport that amounts to 2.38 10^3 t. However, the solid load contributions in March, April and May are not negligible. They totaled a solid loadof

19.12.10^{3} t. The volume disposed of in June and November is significant at 6.82.10^{3} t and 4.33.10^{3} t respectively.

The solid loads recorded in 2016 have fallen compared to those of 2015. A decrease in solid load is observed in June and November, nevertheless June remains the month with high solid inputs with a value of 16.23.10^{3} t. On the other hand, an increase in solid flows is recorded in October and May. However, the volumes of water flow in May, June and October have values that are roughly equal. These values are respectively 3.65.10^{3} m^{3} , 3.81.10^{3} m^{3} and 3.52.10^{3} m^{3} . These volumes conveyed to the Aghien lagoon solid loads of 12.15.10^{3} t, 16.23.10^{3} t and 9.26.10^{3} t respectively. The total for these three months is 37.61.10^{3} t, which is 54.48% of the annual total.

The year 2017 was marked by high loads. Indeed, the months of the long rainy season recorded high inputs, 10.41.10^{3} t, 21.12.10^{3} t, 44.56.10^{3} t and 12.90.10^{3} t respectively in April, May, June and July. Also, during the short rainy season the solid loads transported were 25.49.10^{3} t in October and 14.49.10^{3} t in November. The five months provided the bulk of the solid loads with a value of 128.97.10^{3} t, i.e. a rate of 82.97% of the annual total. The contribution of the long rainy season is 88.99.10^{3} t and that of the short rainy season is 39.98.10^{3} t for a volume of 16.48 10^{6} m3 in the long rainy season and 8.87 103 m3 in the short rainy season. The cumulative flow of seasons is 25.35.10^{6} m^{3} out of an annual total of 39.14.10^{6} m^{3}.

Table 2 Monthly and annual loads of solid inputs to the Djibi (S = 7044 ha).

		jan	Feb.	March	Apr.	May	June	Jul.	August	seven	Oct.	nov.	dec.	total
2015	P (mm)					23.8	535.1	52.4	53.9	14.5	234.5	242.1	11.8	1168.1
	Al (10^{6} m^{3})		0.14	2.37	2.48	3.02	6.82	2.36	2.37	1.84	2.63	4.33	2.03	30.4
	C (mg/L)		8.04	47.34	18.73	17.21	33.27	14.06	14.15	11.87	15.29	23.59	12.43	19.63
	Ss (kg/s)		0	0.06	0.02	0.03	0.14	0.01	0.01	0.01	0.02	0.05	0.01	0.36
	Flux (10^{3} t)		0.24	5.17	5.88	8.07	71.43	3.81	3.37	2	4.88	16.33	2.64	123.82
	Ass (t/ha)		0.03	0.73	0.84	1.15	10.14	0.54	0.48	0.28	0.69	2.32	0.37	17.58
2016	P (mm)	12	40	154.3	88.7	274.4	218.9	24.5	57.3	92	264.5	108.6	132.9	1468.1
	Al (10^{6} m^{3})	1.85	1.92	2.81	2.22	3.65	3.81	1.8	1.99	2.19	3.52	2.12	2.75	30.61
	C (mg/L)	31.38	35.6	52.33	41.27	72.01	79.86	30.39	34.53	40.22	68.05	39.03	51.22	47.99
	As (kg/s)	0.01	0.01	0.02	0.01	0.03	0.04	0.01	0.01	0.01	0.03	0.01	0.02	0.21
	Flux (10^{3} t)	1.9	2.52	6.04	3.96	12.15	16.23	1.79	2.53	3.23	9.26	3.52	5.89	69.03
	Ass (t/ha)	0.27	0.36	0.86	0.56	1.72	2.30	0.25	0.36	0.46	1.31	0.50	0.84	9.80
2017	P (mm)	97.3	117.8	33.2	156.8	207.1	572	196.8	102.2	141.4	467.5	294.3	99.7	2486.1
	Al (10^{6} m^{3})	2.13	2.39	1.71	3.57	3.93	5.72	3.26	2.27	2.31	5.01	3.86	2.98	39.14
	C (mg/L)	37.85	49.27	28.8	72.1	80.79	135.17	64.43	41.15	43.27	105.58	80.04	55.75	66.18
	As (kg/s)	0.01	0.02	0.01	0.03	0.05	0.1	0.03	0.02	0.01	0.06	0.04	0.02	0.4
	Flux (10^{3} t)	3.39	6.06	1.72	10.41	21.12	44.56	12.9	4.92	4.21	25.49	14.49	6.17	155.45
	Ass (t/ha)	0.48	0.86	0.24	1.48	2.99	6.33	1.83	0.70	0.60	3.62	2.06	0.88	22.07

Al: Liquid input; **As**: Solid input; **C**: Concentration of suspended matter; **Ass**: Specific solid input.

3.2.4 Annual variation in solid input

The contribution of solid flows by the tributaries is important and this is due to the aggressiveness of the precipitation which falls on soils without vegetation cover and easily disintegrated and with fairly steep slopes, thus transporting significant quantities of suspended matter through runoff. These inputs are all the stronger when rainfall is abundant (Figure 8).

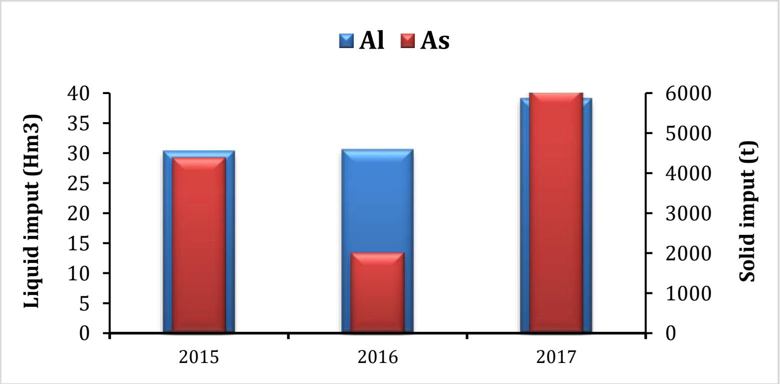

Figure 8: Annual liquid and solid inputs to the Djibi.
(**Al**: Liquid input; **As**: Solid input).

Table 3 is a summary of the calculated annual material flows and solid inputs to the tributaries of the Aghien Lagoon. Over the period 2015-2017, the Mé River contributed huge amounts of solids to the Aghien Lagoon.

Table 3: Annual input balance of suspended solids quantities.

Station	Flux	2015	2016	2017	Total
Djibi	Solid input (10^3 t)	4.39	2.02	6.07	12.48
	Proportion (%)	35.18	16.19	48.64	100
	Liquid intake (Hm)^3	30.40	30.61	37.89	98.89
	Proportion (%)	30.74	30.95	38.32	100

3.2.5 Monthly distribution of solid intake per portion

Figure 8 shows the monthly variation in tributary solids inputs during the study period in percentage contribution. The average monthly contribution reaches its maximum in June at all stations and also over the mirror study period, of a bimodal regime. The maximums observed at the Djibi are 40% in 2015, followed by a drop to 17% in 2016 and a recovery in 2017 (Figure 9).

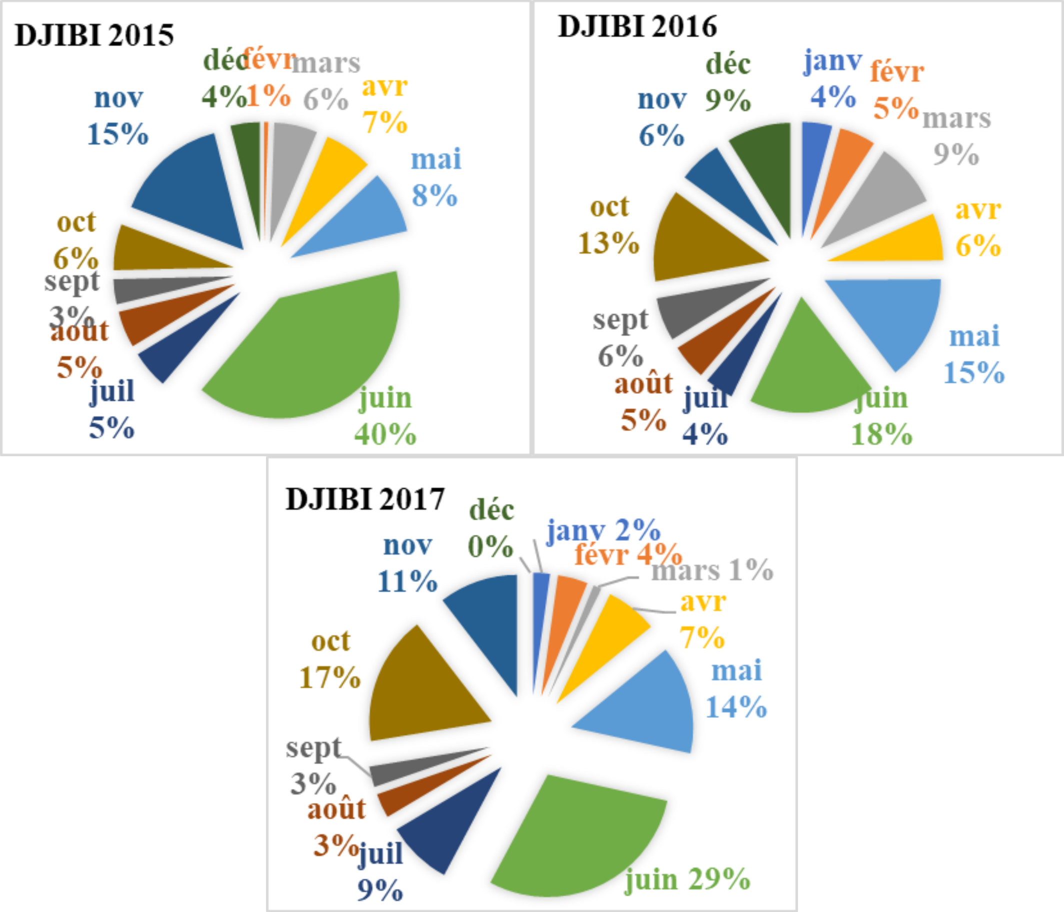

Figure 9: Distribution of monthly solid inputs in percent.

3.2.6 Specific degradation of monthly solid inputs

Figure 10 illustrates the monthly specific inputs over the 3 years of observation. Flows are low from January to March, the months of the long dry season. These flows begin to change in April at the start of the main rainy season and reach maximum values in June, the peak of the rainy season. From this rise, there is a sharp drop from July to September, with September also being the start of the short rainy season, with an irregularity between peaks in October and November for some stations (Figure 10). The observed peaks drop sharply in December, the beginning of the long dry season. At Djibi, a discontinuity or alternation between the minimums. The decrease in rainfall during the short dry season is a consequence of the decrease in solid transport. Minimum values are also observed at this time of year. The specific degradation of the Djibi River in 2015 is significant, with a maximum in June, estimated at 33.85 t/km². The second is in October 2017 with a value of 28.49 t/km².

The highest monthly contribution of specific degradation is recorded in June, more precisely at Djibi (Figure 10). It represents more than a third of the annual solid transport.

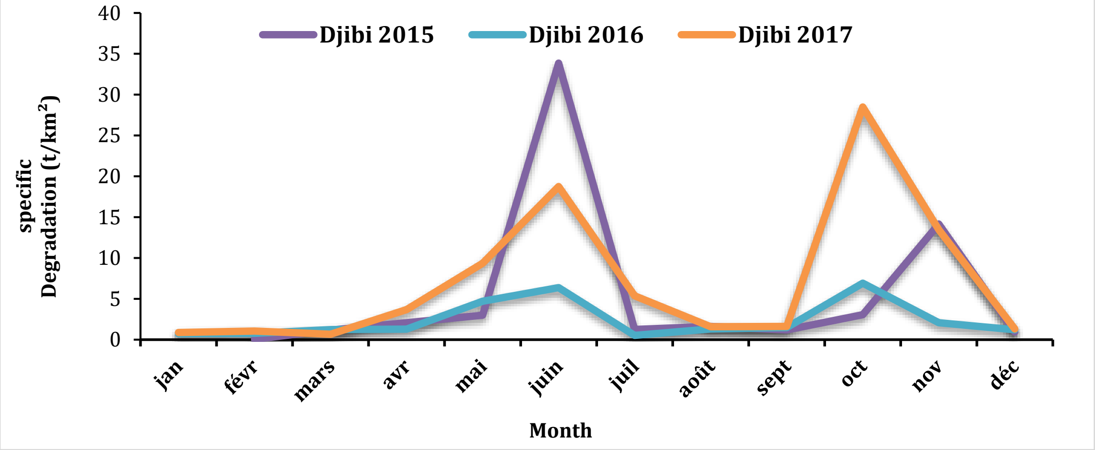

Figure 10: Specific flow of the monthly solid input of the tributaries of the Aghien lagoon.

3.2.7 Specific degradation of suspended solid transport

Figure 11 shows the specific contribution of the Djibi. The waters of the Djibi are more loaded with particulate elements, which indicates the high turbidity of these waters. The annual accumulations in the Djibi are considerable. The interannual average is 59.07 t/km²/year (Table 4). Thus, the solid input in 2016 is less important than in 2015 and 2017.

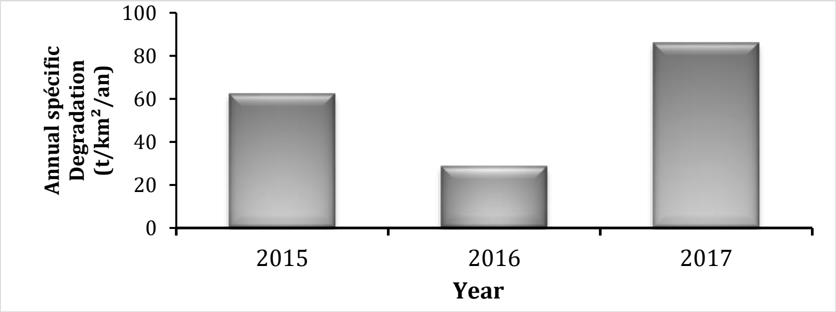

Figure 11: Annual specific degradation.

Table 4: Export balance of suspended solids (Ass in t/km²/year), water flow in flood (Fw mm) and annualrainfall (R mm) in the Djibi River.

Période	**Djibi**		
	Ass t/km²/an	**Fw (mm)**	**R (mm)**
2015	62.35	479.9	1144.3
2016	28.63	434.2	1468.1
2017	86.23	558.6	2486.8
Average 2015-2017	59.07	490.9	1699.7

4. DISCUSSION

The seasonal variation of solids loads on the tributaries of the Aghien Lagoon during the study period indicates that solids inputs are high during the long and short rainy seasons. Also, the concentrations of suspended solids from the rainy seasons are high. High solids loads were recorded mostly in the main rainy season on all rivers.

In the Djibi catchment area, the highest monthly flows occur during the rainy season, notably in May, June, October and November. The flows observed in this season generally come from intense storms in the basin. During 2015, 70.88% of the solid load was transported by the months of June and November: 57.69% in June and 13.19% in November. In 2016, three months share almost all the solid load that was transported to the Aghien Lagoon. The proportion of solid loads is 54.53%, distributed between May (17.60%), June (23.52%) and October (13.41%). The months with solid loads in 2017 are also May, June and October, the cumulative solid input portion of these three months is 58.65%. The proportion of each month is 13.59% in May, 26.67% in June and 13.40% in October. The assessed annual solid load on the Djibi River during the study period is $123.82.10^3$ t/year, $69.03.10^3$ t/year and $155.45.10^3$ t/year, and the resulting specific degradation rate is 17.58 t/ha/year, 9.80 t/ha/year and 22.07 t/ha/year in2015, 2016 and 2017 respectively.

The solid loads transported in high water are higher than in low water. The specific degradation found over the study period is significant on the tributaries of the Aghien lagoon. Although the size of the catchment areas seems to influence these values, the Djibi catchment area is relatively affected by this phenomenon even though it is not the largest. The

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decrease in annual specific degradation with increasing catchment area could be due to the variation in the ratio between the amount of sediment removed from the slopes and the riverbed and the amount of material that remains trapped in the catchment before reaching the outlet due to transfer discontinuities. When the surface area of the basins increases, the proportion of areas with low slopes (valley bottom, floodplain) increases, thus favoring sedimentation phenomenaon the one hand and reducing the relative proportion of sediment sources on the other. The values of the specific sediment supply recorded are largely superior to those found by Lako et al., (2010) [25] on the Sassandra, which is 12.9 t/km²/year witha surface area of 75,000 km². The values are also higher than the value of specific degradation recorded by Droux et al., (2003) [26] on the Dounfling (17.5 km²), Djitiko (103 km²) and Bélékoni (120 km²). They are also higher than the value of (18) on the Oued Kebir Hammam watershed (1130 km²) which is 258 t/km²/year. On the other hand, the specific degradationvalues of the Djibi catchment are within the range calculated by Bouanani (2004) [27] which is 120 to 3657 t/km²/year on the Sikkak (463 km²). Furthermore, the estimated sediment loads over the three study years (2015, 2016 and 2017), indicate thatthe years 2015 and 2017 are characterised by very high solid inputs. This could be explained by the abundance of exceptional floods in volume and duration. On the other hand, the low sediment input in 2016 on all tributaries of the Aghien lagoon could be explained by the low rainfall recorded. The sediment input could contribute to the silting up ofthe Aghien lagoon water body. Furthermore, most of the sediment or fine particles transported from upstream to downstream of the basin do not all reach the outlet of the Aghien lagoon. A large amount of the particle is depositedat the bottom of the lagoon because of the low slopes and the speed of the lagoon water body, causing it to fill up. According to Noumon et al., (2019) [28], the transport of suspended solids is the main cause of the filling of water reservoirs.

5. CONCLUSION

Suspended solids transport in the sub-catchments of the Aghien lagoon was calculated over the four seasons, namely the long and short rainy season and the long and short dry season. The solid flows vary according to the liquid flows according to a power law. From this relationship, the solid flow was extrapolated. The annual tonnage of solid matter transiting through the Djibi was deduced from the power law for all seasons. The quantity of solid matter amounts to $348.3.10^3$ t/year, which corresponds to a specific degradation of $4.94.10^3$ t/km²/year. Furthermore, in 2017, the Aghien lagoon received important solid loads, the values of these solid inputs are 0.16.106 t/year coming from the Djibi river. The results of the suspended solids analysis allowed the identification of the different seasonal inputs. However, the annual solid inputs are estimated at $348.3.10^3$ t/year with a specific degradation of 4944.45 t/km²/year at the Djibi from 2015 to 2017. This study has shown that the Djibi River carries enormous amounts of material flows to the Aghien Lagoon.

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