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Degradation of *loumou* Track through Ruts in Brazzaville Western Periphery: Forms Characterization, Traffic and Rainfall Aggressiveness Analysis (Republic of Congo)

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ABSTRACT

The Sadelmie-Loumou-Nguidi trail, known as the *Loumou Road*, located in Pool department, in the south of the Congo and nearly 35 km long, has been affected by the rutting phenomenon for more than 10 years mostly in *Case Barnier-Ntoba ilele* section. This anthropogenic erosion phenomenon, which impedes the mobility of people and their goods, access to basic social services, the disposal of a few agricultural products and trade with Brazzaville, is due, on the one hand, to traffic aggressiveness and rains aggressiveness. Between 2014 and 2016, the Daily Average Traffic (DAT) on this runway was 88 vehicles per day (V /D). This DAT > 50V/D expresses a strong traffic aggressiveness on this track. The traffic and vehicles weight about all categories leave marked traces of wheels on the wet road during the rainy period from September to May. The concentrated runoffs exploit these traces which rapidly evolve into ruts and later into gullies. These runoffs are due to the 1 400 mm mean yearly rainfall volume (MYRV) recorded to Maya-Maya Climate Station in 10 years (2005-2014). The rainfall aggressive indices evaluated from this MYRV yield 67 for Fournier index (FI) and 7,757 MJ.mm / ha.h.an for rainfall erosivity index (R). These indices express a strong aggressiveness of the rains in the area. But these parameters influence largely the running surface sensitivity of this track, whose reworked material is dominated by *Batékés* sands, very erodible about rainfall, with an erodibility index (K) between 0.35 and 0.45 t.ha.h / ha.MJ.mm. The aim of this study is to show that this minor erosion phenomenon is part of the main models of anthropogenic erosion that degrade the Loumou road and seriously affects the socio-economic development of villages along this track. To this end, it characterizes the ruts and analyzes the signs of traffic and rainfull aggressiveness, which are genesis and evolution factors of the ruts on this track.
KEY WORDS: Congo, Pool, dirt track, ruts, anthropogenic erosion, aggressive traffic.

1.INTRODUCTION

Western Brazzaville, administered by Goma Tse-tse sub-prefecture, has been affected by slopes degradation for almost 20 years. This degradation, which is controlled by water erosion, is initially manifested by potholes and gullies, which in turn evolve and sometimes quickly in spectacular gully that cut and / or shrink the roads. But other tracks in the region are affected by a form of erosion typical of dirt tracks, it is *ruts*. Initially, these forms are nothing more than the wheel tracks of vehicles, which worsen by vertical deepening due to the combined actions of traffic and concentrated rainfall runoff. The whole process called rutting, manifests itself much more on wet tracks. These forms are thus precursors of a very marked tracks degradation which evolve later in longitudinal gully. The Sadelmie-Loumou-Nguiri runway linking western Brazzaville and the northwestern Goma Tse-tse sub-prefecture is greatly affected. The forms high density and sediments high rate produced by this phenomenon, have noticeable geomorphological effects on the slopes and the lowlands of drained valleys along this track. The traffic that once facilitated the Brazzaville rallying to Mayama and Kindamba sub-prefectures in extreme Pool region north-west, has been difficult for nearly two decades. Today, because of the forms proliferation on this socio-economic importance road, some villages like *Nguidi*, *Lengo* and many others are quasi-enclaved. This isolation accelerates the phenomenon of rural exodus to Brazzaville, because of famine and the lack of basic services (hospitals, schools, etc.) and therefore, curbs socio-economic development because of the poverty of resident populations. This study describes the phenomenon (genesis, evolution and consequences) and analyzes the causes and the factors that are responsible for it. The aim is to show how a minor erosion phenomenon, poorly managed, is responsible for a major roads degradation.

1. 1. Study track presentation and its natural environment

This so-called Loumou track begins at the exit of Sadelmie district, after "the city of 17" (Moukondo), in the northwestern Brazzaville outskirts at 4°13'27.8"S and 15°13'54.5"E. It serves the area of "Case Barnier", a military post adjoining N'tsouélé and Ntoba Ilélé villages (4°11'33"S and 15°08'52"E) at 360 m of altitude, the large village Loumou (04°09'22.4"S and 15°08'56.1"E) at 332 m above sea level, crossing the river that bears the same name and reaches the village Nguidi still called Louweto to extreme north-west of sub-prefecture over 35.46 km (Figure 1). At Brazzaville exit, this track which was tarred in the 80s, under the five-year plan, until the "Case Barnier" on 5.76 km, is in full degradation by minor forms such as nests- hen, ditches, wrinkles and faïençages that destroy the bitumen that is the wearing course, on this section. Apart from the degradation by these minor forms, nearly 5 large regressive ravines have been threatening the road since 2015. From *Case Barnier*, the road is in the ground to *Nguiri* through *Ntoba ilélé*, Loumou. Located on the plateau of Mbé, the track crosses a rugged topography dominated by hills with sloping sides with slopes that sometimes exceed 25%. This topography places certain sections of the road in a situation of interfluve, others in terrace position, still others in the valleys valley bottoms. It crosses a valley drained by the river Djouari, the most important of the zone. Geologically, this

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track has been traced on Tertiary formations, made up of Batékés sands, which covers nearly 635 km^2 and rests naturally on the sandstones of the Inkisi. This formation bequeathed to this zone, ferralitic soils very desaturated. These are remodeled soils characterized by a mixture of sands and clays described by [7], which are generally sensitive to water erosion.

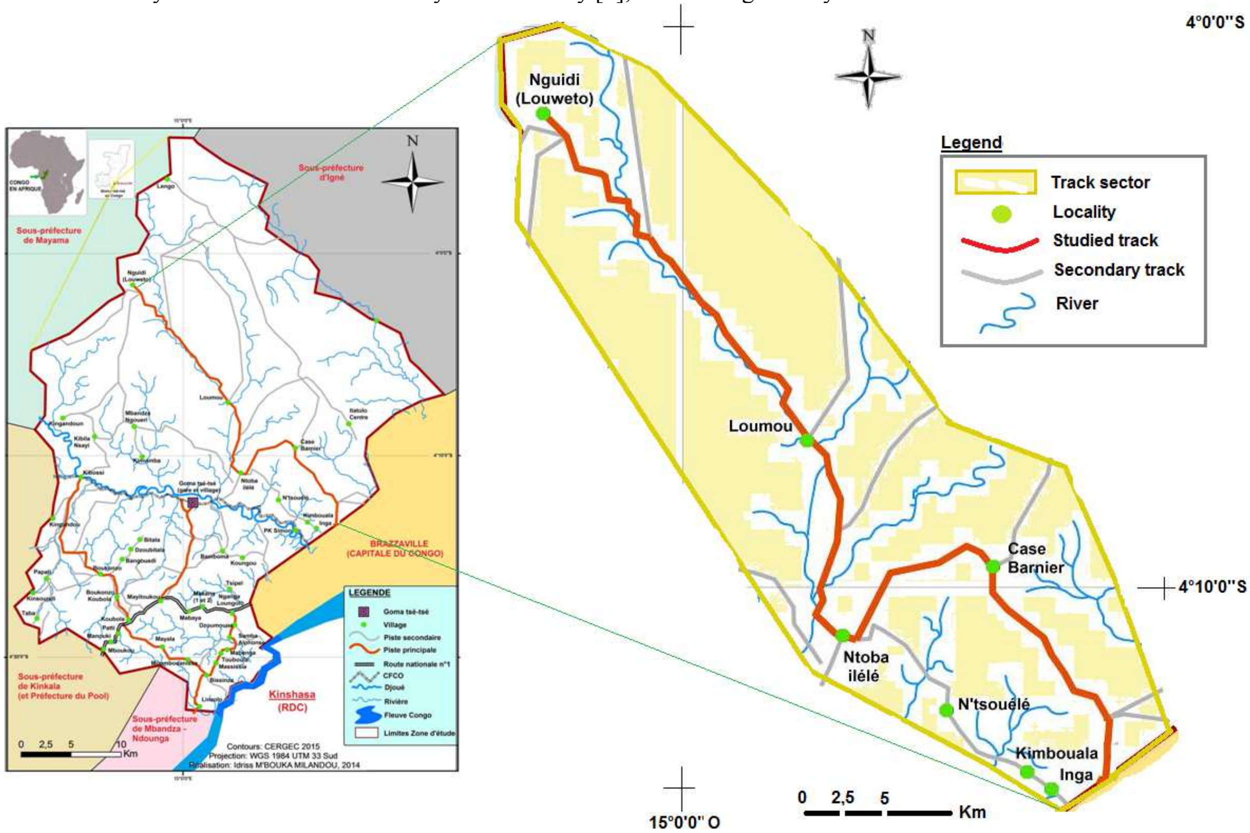

Figure 1: Loumou track localisation, in south of Goma tsé-tsé sub-prefecture

The area climate is that of Brazzaville, tropical hot and humid, with a rainy season of nearly 8 months, from mid-September to mid-May with annual rainfall amounts of nearly 1 400 mm, temperatures that vary between 28 and 34°Celsius. As for dry season, it lasts for 4 months, from mid-May to mid-September with rainfall monthly that does not reach 10 mm. It's the year coolest season, between 22 and 25°Celsius. Vegetation is dominated by low, sparse savannahs that run along the track on the peak sections and hillsides, but also along sections on the valley slopes. The drained shallows are the domains of woody formations made up of rain forests, along the waterways in the Barnier - Loumou area. But from *Loumou* to *Nguidi*, it is the low savannah that dominates for nearly 15 km.

2. MATERIAL AND METHODOLOGY

The collection of written and cartographic data on the study area, the track layout, and the rutting phenomenon around the world was the first step in this research. Then, it was question of observing and directly analyze the ruts on this track between 2014 to 2016 and finally to study the traffic and rains aggressiveness.

2.1. Phenomenon observations and mapping

The ruts that "scuffed" the running surface of the Sadelmie-Loumou-Nguidi runway were observed with the aim of phenomenon describing, taking into account the forms genesis, their spatial evolutions and their traffic, geomorphology and environment consequences. For this purpose, a Toyota BJ 4x4 vehicle was used to cover nearly 35 km of track for direct rutting sessions. These were photographed from a 20 Megapixel Sony digital camera. The mapping was done on an ArcGIS 10.1 GIS. A tracing map of the northern part of Goma tse-tse with the runway under study was obtained at CERGEC. It has been used for all operations of track mapping and area most affected by rutting. To do this, a Magellan GPS was used in the field during the first operations mentioned above, with the aim of identifying the track geographical coordinates, on each village to the terminus at *Nguidi*. On the one hand, and to georeference the most affected track section by ruts, on the other hand. However, because of the high density and their length sometimes exceeding 100 m for some and their very low volume for others, the ruts have not been georeferenced. Georeferenced mapping focused only on the road and the most affected area by ruts.

2.2. Analysis the traffic aggressiveness

It focused on the daily enumeration and vehicles typology using this runway. The purpose of this operation is to estimate the average daily traffic on this track and to categorize, by size, the vehicles types that use it. These two operations were carried out during the

2014-2016 period. 2 points of entry and / or parking were chosen: the district Sadelmie terminus, towards Moukondo (Brazzaville) and the Loumou village, located at the crossroads of 03 tracks sections: Sadelmie- Case Barnier- Ntoba Ilélé-Loumou (section 1); Loumou-Nguidi (section 2) and Loumou-Nguidi-Lengo (second axis abandoned). 01 person at each point was responsible for vehicles enumeration from 6 h to 18 h. This work involved all commercial and personal vehicles use.
The ultimate objective about these operations is to evaluate traffic aggressiveness on this runway, using [24] model, which consists in classifying the daily traffic taking into value account about 50 vehicles per day (50V/D), as an evaluation traffic index on unpaved road, from proposed table by [24] (Table 1).

Table 1: Traffic classification on Unpaved Roads

Average Daily Traffic (ADT)	Type of traffic
ADT < 50V/D	Low
ADT = 50V/D	Way
ADT > 50V/D	strong

Table established according to the classification of [24].

2.3. Rainfall data collection and processing

The proximity of the Sadelmie-Loumou-Nguidi axis to Brazzaville city and *Loumou* rainfall station inactivity nearly 20 years, forced us to use rainfall data from 2005 to 2014, about Maya-Maya climatic station. These data made it possible to determine the rains erosive capacity, starting from two indices: the Fournier index (FI) and rains erosivity index (R). The first makes it possible to evaluate the aggressive nature of climate with regard to soils. It has been used in the world to estimate soil losses and development projects. [13] defined it as the ratio between the wettest month precipitation on the year (p) and total annual precipitation (P) using the formula:

$$FI = \frac{p^2}{P}$$

p = wettest month rainfall; P = annual rainfall

The results were analyzed using [16] model, which consists of 5 distinct classes used with the modified Fournier Index (Table 2).

Table 2: FI classes, description and category

Classes	Description	category FI
1	Very weak	<60
2	Low	60-90
3	Way	90-120
4	High	120-160
5	Very high	>160

Source : [16]

As for the rainfall erosivity index (R), it was used to check and compare the effective rains aggressiveness with the first index (IF) respect. For this purpose, we took into account the simplified [22] formula. This index is defined as rain ability to cause erosion. It mainly depends on rain intensity or kinetic energy that directly results. But due to a lack of total rainfall data and 30-minute maximum rainy episodes intensities in 30 years, we used the simplified formula proposed by [22] which incorporates only average annual rainfall (P) in mm. from the principle of the volume of precipitation according to: P <850 mm or P> 850 mm according to the world each region. Out in Maya-Maya, rainfall exceeds 850 mm. Hence the formula:

$$R = 587{,}8 - 1{,}219\,P + 0{,}004105\,P^2$$

R: erosivity parameter; P: annual precipitation (mm)

The results were analyzed from the established R classification of [8] (Table 3).

Table 3: classes of rainfall erosivity indices

Class	Erosivity (R)		Soil Vulnerability
4	> 5000	High erosivity	Very high
3	4000 à 5000		High
2	3000 à 4000		moderate
1	2000 à 3000		Low
0	0 à 2000	Low erosivity	Very weak

Source : [8]

3. RESULTS AND DISCUSSIONS

3.1. The ruts genesis and evolution

According to [18], ruts are longitudinal deformations permanent at vehicles' wheel wells (Photo 1).

Photo 1: trace of wheels and beginning of rutting in the area of Loumou schools

Photo 2: beginning of aggravation of the ruts at the entrance of the village Loumou

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In extreme cases, roadway has a W profile. They are due to strong traffic influence, both in terms of intensity and characteristics such as speed, loads (weight) and cross-sectional distribution. Ruts are all more marked as traffic is heavier and more channeled. For [9], these are traces left by vehicle wheels driving on the track wet and are presented as permanently longitudinal grooves present in the treads (photo 2). These are often the starting point for dirt tracks degradation. With these two clear definitions, the ruts evolution has been described by several researchers, including ourselves in a previous study [25]. Previous studies show that as vehicles travel on the same tracks, these furrows sink further under the concentrated runoff effect which, due to drainage systems lack, contribute to their gradual deepening.

3.2. Rutting Consequences on Sadelmie-Loumou-Nguidi axis

According to [20], from 200 millimeters deep on a road section of 20 meters of length, the track becomes impassable for medium-sized vehicles (sedan). These forms are at enormous loss root of materials that upset the geomorphological balance on the slopes of both roads sides and in dry and drained bottoms. In drained valleys, these materials sediment streams and rivers and pollute the biotope. As a result, [11,12] state that when unpaved runways are affected by ruts, they produce sediment quantities that can increase two to four times compared to freshly graded (lateritic) roads.

Photo 3: Evolved ruts in linear channels to Ntoba Ilélé

Photo 4: Evolved gutters at the exit of Case Barnier

Photo 5: Evolved rut in gully near Ntoba Ilelé

Photo 6: Evolved rut in longitudinal gully at the exit of Case Barnier

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For this purpose, when a rut is formed, it runoff channels concentrates the incise further. This concentrated flow continues until it passes the rut or a cross flow is encountered. In severe cases, rut can channel water over long distances and bypass relief culverts or drains [12].

The relatively steep incline of more than 7% of the track at *Case Barnier* to *Ntoba Ilélé* and an average of 5% of *Ntoba Ilélé* in *Loumou*, allow runoff to quickly exploit ruts that often turn into linear ditches (Photos 3 and 4) and later in ravine (Photos 5 and 6). Hence the increased erosion on this track, which, in addition to being threatened by regressive ravines at the level of the Sadelmie-Case Barnier bituminous section, undermines the safety of the users and populations life area. According to [18], once formed the ruts hinder the vehicles lateral movements, forcing them to roll on the same furrows, which amplifies their development. In many extreme cases, their depth is such that the axles of heavy vehicles touch the ground, making the roadway impassable for light vehicles. On some tracks in the plateau of Cataractes, these ruts are the starting points of overcrowded dirt tracks, described by [25]. But if in Morocco and the USA, rutting dirt tracks blocks light vehicles, on the Sadelmie-Loumou-Nguiri axis, this phenomenon can even block all-terrain vehicles (4x4) movement (Photo 7) and even heavy goods vehicles (Photo 8), because the very compact rut between the ruts is an obstacle for the chassis of small vehicles.

Photo 7: 4x4 vehicles blocked by the ruts towards Nguiri. Borrowed image

Photo 8: heavy truck in difficulty rolling due to severe ruts to Case Barnier

Photo 9: temptation to treat a rut to facilitate the passage of the heavy vehicle in the photo 7.

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This situation is frequent in the road sector located between Case Barnier and the Ntoba Ilélé village, which stretches for nearly 10 km. This is the area most affected by rutting on this runway (Figure 2).

Faced about this impractical situation on this runway section, drivers have created deviations in the savannah, to get around the area and easily reach Ntoba Ilélé. The ruts gravity in this zone is coupled with the silting phenomena, which on the one hand is due to the geological nature of the area, dominated by sandy formations of the Tertiary, very erodible, with an erodibility index (K) between 0.35 and 0.45 t.ha.h / ha.MJ.mm [19], on the other hand, by the fine erosion that occurs upstream of the track towards the *Case Barnier* area and on sandy road slopes with gentle slopes and fairly stable thanks to the vegetation. This erosion is related to the aggressiveness traffic and rains on zone but also to anarchic occupation of the lands dedicated to the construction of the houses and to the agricultural activities.

3.3. Causes and aggravating factors

3.3.1. Traffic aggressiveness on the track

Table 4 and Figures 3; 4; 5; 6 and 7 characterize the vehicles types used on Sadelmie-Loumou-Nguidi runway, as well as their number, taking into account the average number of commercial (ANC) and personal (ANP) vehicles. From these results daily average (DAT), monthly (MAT) and annual (AAT) traffic were also deducted.

Table 4: Traffic Characterization on Sadelmie-Loumou-Nguiri runway

Section	Number and vehicle types			ANVp	ANVop	Traffic		
	Sedan	4X4	Heavy weights			DAT	MAT	AAT
Sadelmie- Case Barnier – Ntoba Ilélé (S1)	50	21	9	10	70	80	2 400	28 800 (90.91%)
Ntoba Ilélé-Loumou-Nguiri (S2)	1	2	5	0	8	8	240	2 880 (9.09%)
Total	51	23	14	10	78	88	2 640	31 680 (100%)

Note 1: ANVp: Average number of Vehicle/ parking; ANVop: Average number of Vehicle out of parking;
Note 2: TMJ: daily average traffic; TMM: monsuel average traffic; AAT: annual average traffic

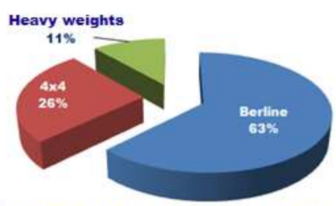

Figure 3: Rate of vehicle types on Section 1
Sadelmie- Case Barnier-N'toba ilélé

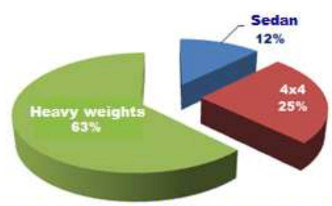

Figure 4: rate of vehicle types on Section 2
N'toba Ilélé-Loumou-Nguidi

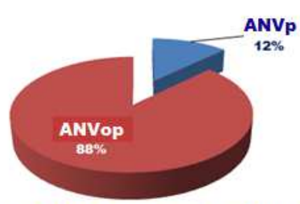

Figure 5: Rate compared to ANVp and ANVop on Section 1

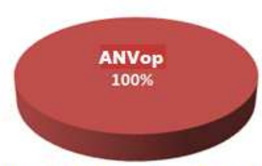

Figure 6: Rate compared to ANVp and ANVop on Section 2

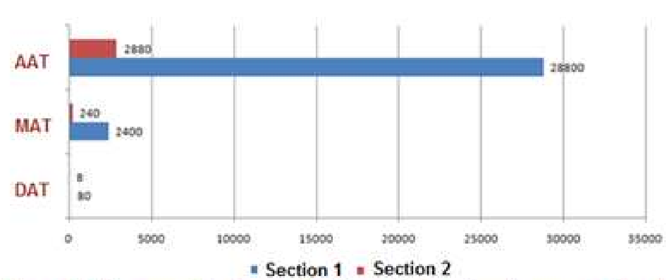

Figure 7: Daily, monsuel and annual traffic on the 2 sections between 2014 and 2016

In Figures 3 and 5, the section *Sadelmie - Case Barnier* (5.76 km asphalted) - *N'toba ilélé* (nearly 7 km earth), the light vehicles rate (sedan) reaches nearly 63%, that of all terrain is around 26% and finally almost 11% for heavy goods vehicles.
These rates reflect the reality that 88% of all vehicles categories excluding parking (personal, service, military, etc.) use this section, compared to only 12% listed in the Sadelmie car park. These rates, in terms of vehicles number, reach 80 vehicles per day, all categories combined, for 2,400 vehicles per month. This number, which exceeds the average of 50V/D, thus expresses a notorious aggressiveness on this first section (Table 4). This makes a total of nearly 28,800 vehicles per year between 2014 to 2016. It is in these conditions that this section is much sought and deteriorates so quickly. This degradation concerns even the bituminous part, affected by rills, potholes, etc. Further, it is great regressive ravines that threaten it. The *Case Barnier* and *N'toba Ilélé* sections are the most affected in terms of rutting (Figure 2). This is the most difficult part for the very traffic of all-terrain vehicles and trucks during rainy and dry seasons. The ruts observed in this area have reached worrying levels, as shown in photos 3; 4 and 5. Some forms have become gullies (photo 6). Even attempts to process said forms are failing. On the *Ntoba Ilélé - Loumou-Nguiri* section, traffic is low: 1 sedan (12%), 2 vehicles 4x4 (25%) and 5 heavy goods vehicles (63%) per day (Table 4, Figure 4). The overall low number of sedans is justified by the very sandy nature of track. Hence the ANVp is zero and the ANVop is equal to 8 or 100% (Figure 6). This shows that this section is not popular with the public transport vehicles booked in the *Sadelmie* car park. This is also due to the degradation of the first section, although some deviations have been created in the savannah. For this purpose, the DAT makes 8 vehicles per day < 50V /D, or 240 vehicles in all categories, with a low total of 2,400 cars in year (Table 4). However, according to [21], on some resource roads, the passage of more than four trucks per day is considered significant traffic and may result in flattening or rutting.

However, taking into account all the traffic on the entire track, the DAT reaches 88 vehicles per day, a number well above 50V / D, with a light vehicles dominance whose number reaches 51, followed by vehicles 4x4 which graze 23 and finally the trucks that barely exceed 14 number. But according to [1], the tracks are attacked by the passage, in large part, of heavy goods vehicles. For latter "the term aggression means the damage caused to a roadway by the passage of one or more axles". Overall, the *Sadelmie-Loumou-Nguiri* runway is in increasing aggression every rainy season. For this purpose, [18] stipulates, in a technical report on runways degradation, that: *the strong traffic influence, both in terms of intensity and characteristics such as speed, loads and transversal distribution, the ruts are all the more marked as the traffic is heavier and more channeled*. Finally, this statement is consistent with the analysis of the [4], which states that road deterioration generally depends on trucks number and weight that use it.

3.3.2. The roadway sensitivity and anti-erosion measures deficiencies

The traffic aggression effects are accentuated by roadway sensitivity due to the lack of an adequate wearing course, the drainage system lack and maintenance lack. At this level [24], indicates that *"an unpaved roadway is much more affected by associated traffic or not with the rainwater through the runoff which interact with the natural environment (topography and type of soil)"* . The proper rolling layer lack is, according to [3], a fairly important factor in pavement degradation, because a road is sized to support a number of vehicles and a given frequency. This assertion is also supported by [2], who believe that traffic has consequences for sediment stripping on the road surface of rural and forest roads. [10], reinforced this idea in these terms: *"traffic can have a significant effect on roads erodibility, through: the rutting development; the aggregates pressure of the reworked material in the subsoil, decreasing the hydraulic conductivity and increasing the rates of erosion and erosion; the aggregates decomposition, which become susceptible to erosion and compaction of the running surface, which makes the runway very erodible "*. Similarly, according to [16], traffic-intensive roads or roads with poorly maintained surfaces can move from a flattened transverse to a large rutting. Concentrated flow in the ruts has a higher shear stress, which increases its ability to erode and transport sediments, thereby increasing erosion. This analysis is reinforced by Bilby & al. (1989), Reid (1981), Reid & Dunne (1984), and Swift (1984b), cited by [15], who state in these terms that: *"shown to be significant to sediment production from road surfaces "*. This means that traffic intensity and vehicle types affect many of the physical parameters that cause sediment stripping on the road. Similarly for Fahey & Coker (1989), Foltz & Burroghs (1990), Haydon & al. (1991), cited by [15], traffic destroys surface material, resulting in rolling surface degradation and increased transport of sediments from the road. Traffic can also produce road ruts.But in Mbé and Cataractes tray in Congo, the pedo-geological complex characterized by a mixture of the sandstones of *Inkisi* and *Batékés* sands, favors the ruts rapid formation on dirt tracks. The wheel tracks of vehicles do not take time to evolve into ruts. The lack of rainwater drainage system causes the stagnation of rain on the roadway, which wets it further and causes it to become engorged. It only takes a succession of rain and a repeated passage of light or heavy vehicles, so that there is ruts multiplication and runoff concentration in these furrows.

3.3.3. The rains aggressiveness

Table 5 and Figure 8 show the results and trends of IF and R index evaluated from rainfall data from 2005 to 2014 obtained at Maya-Maya climate station.

Table 5: Precipitation, IF and R index between 2005 to 2014

Years / Index	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Moyenne
p (mm)	272,4	361,3	351,6	466,0	284,2	237,3	376,8	224,2	310,8	248,2	313,28
P (mm)	1326	1364,8	1701,6	1642,8	1539,2	1329,7	1675,7	1198,4	1596,6	1293,7	1466,85
IF	55,92	95,65	72,65	132,19	52,45	42,35	84,73	41,94	60,50	47,62	66,91
R MJ.mm/ha.h.an	6 189,1	6 570,4	10 399,3	9 663,8	8 436,8	6 225	10 072	5 022	9 105,7	5 881,2	7 756,6

Notes: p (mm): rainfall of the wettest month; P (mm): annual rainfall;
FI: Fournier Index

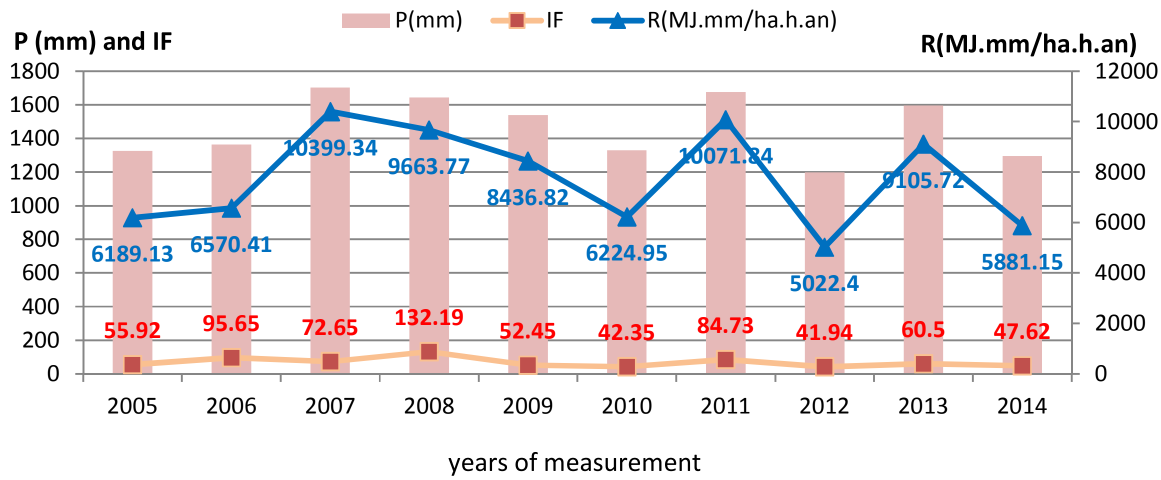

Figure 8: FI and R index combined rainfall chart

The results show that IF average is estimated at 66.91. This index is higher than the values found respectively by [26] in Yaoundé (Cameroon) and [17] in Po Tibelé (Burkina Faso) close to 50. But, if we take into account the [16] model, he is weak. This is why we relied on the Fournier index by year. It has been found that for some years the IF index is more aggressive than for others (Figure 8). This is 2008 case which is the wettest year, with an IF nearly 132, even reaching the peak. It is classified in 4 category, which indicates a high climatic aggressiveness [16], followed by 2006 year, with an index close to 96, it is classified in 3 category, justifying a climate moderate aggressiveness. According to some accounts, these two years were the most severe in terms of ruts proliferation on this track, especially at the *Case Barnier-Ntoba ilélé* section. These periods also correspond to the creation of several deviations in savannas to circumvent the rutting. It took the intervention of the Chinese public works company CRBC which had backfilled the track for vehicles to circulate.

2007; 2011 and 2013 years, have average IFs as the values vary between 60 and 90 (second class) and the weakest years in terms of aggressiveness are 2005; 2009; 2010; 2012 and 2014, as their indexes are below 60. As for the R index, the results show that with an average of 1,466.85 mm of annual rainfall in 10 years, the R factor average is estimated at 7,756, 55 MJ.mm/ha.h.year. Taking into account the [8] classification, this index is in 4 class and has a very high erosivity, since it is well above 5000 MJ.mm/ha.h.year. For this purpose, soils are vulnerable to these rainfall volumes. [6] who estimated soil moisture erosion using USLE in the Balan gully catchment in Haiti, for 7 years (1990-1996), with rainfall events greater than 12.7 mm, found an erosivity index estimated at 8097.96 MJ.mm/ha.h.year, quite close to the one we found in Brazzaville and the surrounding area. In view of our results and those obtained by some authors cited above, it is necessary to question the factors of index variation of aggression rainfall in the world. [27] have even claimed that this trend or variation in rainfall aggression increases as one moves towards the southern hemisphere. In the face of this ambiguity, we relied on the values of R per year to establish a link with the rutting crises on this track. It was found that for two years 2012 and 2014, R vary between 5,022.40 and 5,881.15 MJ.mm/ha.h.year (class 3), showing a high soils vulnerability in rainfall face. But years rest have erosivity factors higher than 5000 MJ.mm/ha.h.year, expressing a high erosivity and a very high soils vulnerability in the face of Brazzaville rains and its surroundings. 2007; 2011 and 2008, even exceed the threshold set for R expressing a strong aggressiveness, since the R index values far exceed 5 000 MJ.mm/ha.h.year reaching respectively 10 399.34; 10,071.84 and 9,663.77 MJ.mm/ha.h.year. Crossing of R results in relation to rains volumes and some field rutting surveys crisis periods, reports that three most erosive years cited above were periods at which rutting was more severe. 2007 year was the most catastrophic according to the populations. Taking into account the average annual R Index (USA) comparison chart, proposed by Roose (1981) quoted by [14], the R index values found in the area are and even exceed the R average classified in the subequatorial zone (Table 6).

Table 6: R index (USA) comparison and some world regions

Regions or countries of measurement	$R_{(USA)}$ average annual
USA	50 – 550
Mediterranean area	50 – 350
Dry tropical zone	200 – 600
Subequatorial zone	500 – 1400

Note: table modified by us.
Source: Roose (1981) in [13]

Although the erosivity and Fournier index combination shows no correlation between its two indices (Figure 8), despite the use of the same data of rains volumes, but the runoff produced by these aggressive rains have an erosive effect on this track because the slopes are sensitive, in terms of degree that exceed 7% and length that exceeds 100 m.

These large runoffs during the rainy season directly affect running surface of the runway plotted on a topographically rugged area, with slopes often exceeding 25%. The superficial stripping is facilitated by the sensitive nature of the redesigned material (RM) constituting the running surface, whose apparent density, according to [25] vary between 1.7 and 1.8 g / cm3. This RM comes from sandy geological formations of Tertiary, also called Batékés series, with about 90% of sands [7, 25]. These formations have an average porosity about 30% [25], whose porosity index (PI) is estimated at 40.59. Or PI> 3, indicates very porous formations and confirms the sandy nature of soils support and the running surface of Sadelmie-Loumou-Nguiri track. But despite their appreciable infiltration capacity, the fact of not blocking the runway during and a few hours after each rain, the infiltration is compromised, because traffic and the vehicles weight with the wet running surface, create wheels traces that can overcrowd in a single rain and become ruts that spread over hundreds of meters. This is why we rely on the idea that ruts genesis and evolution are controlled by the traffic, the water and the tracks RM sensitivity.

4. CONCLUSION AND PROPOSED SOLUTION

Ruts are minor forms of erosion that affect earth tracks in general and Loumou road in particular. This track is more and more impracticable, despite some created deviations in the savannahs, by motorists. This causes the entire villages isolation such as *Nguidi* and *Lengo*, with consequences about access to basic social services and constraints in agricultural products and other goods sale, and trade between the riverside villages and Brazzaville. This is why this type of tracks degradation, should be taken seriously. For this purpose, two types of solutions can be recommended:

- The first is to avoid ruts genesis, making rolling surface consistent, during the works management and/ or rehabilitation. This consistency lies in materials quality used in the track layout, followed by good compaction. The best materials for track management and rut mitigation are laterites. These are resistant to traffic and vehicle weight. The runway should be maintained regularly to delay rutting. After the management and/or rehabilitation works, it is possible, according to Foltz (2003) in [10], to mitigate rutting by traffic limiting during the rainy season. That is, close the runway to traffic during and after a few hours of rain, to allow water infiltration or evacuation off the roadway. The low traffic stabilizes the running surface of the tracks and proportionately decreases the erosion. But erosion can return as soon as car traffic resumes in the rain or a few minutes after the downpour;
- The second solution is to effectively treat the ruts, avoiding to level the bearing surface all the time to make them disappear. Apart from the lateritic tracks which can be leveled in order to correct the surface disturbances, the dirt track is not favorable for this kind of work. According to [25], repetitive leveling is at the"overcrowding" phenomenon origin, which is a track transformation into a real trench. In this case, the solution is to backfill the track with consistent materials supported by good compaction of the roadway with mechanical equipment.

The work rest is the rainfall runoff control, through the development of water drainage works (gutter, ditch, culverts or culvert) taking into account the running surface bulging of the track and environment to properly water evacuate. Without water control, the two recommended preventive and curative solutions will be ineffective and the ruts, like other forms of minor erosion, will be omnipresent despite the good quality of the work.

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