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NOISE IMPACT ASSESSMENT OF URBAN TRAFFIC "ROADS AND TRAMWAYS"

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ABSTRACT

To assess the noise impact of the vehicles and tram traffic in Rabat city, "AGDAL district", we have studied the variation of the overall noise in the main streets during two periods (day and night), subsequently, we have used a free model to simulate the noise on the whole of the district. Finally we compared the real reference state in some measures points with the simulated results by the plugin, "noise map".

Keywords: environmental impact, noise pollution, road traffic, tramway traffic, modeling, Gis, Noisem@p.

INTRODUCTION

Given the increased traffic in Rabat City in recent years, roads have become unable to absorb a large traffic of light and heavy vehicles at the workplace.

The ministry of equipment, transport and the logistic, and the management agency of the Bouregreg Valley, have planned in the development plan to achieve structuring projects such as the tram.

The tramway has been inserted in the main streets of the city, linking the main areas in Agdal district to downtown.

The enlargement of the main roads and streets, and the renewal of the pavement, has been a positive impact on the traffic flow at the city.

The present study consists to measure and modelize the effect of noise generated by the traffic of heavy, light vehicles, and tramway. Finally we'll compare the difference between real and simulated noise in Agdal district.

The world is witnessing an exponential rise in the number of vehicles on the roads, leading to an increase in the traffic noise levels. The high noise levels have been shown to affect the health and well-being of a considerable section of society, especially those living in close proximity of railways and urban roads [7], [1], [2], [8].

Have shown that in many cases the noise levels are higher than the prescribed limits set by the regulating agencies, for a particular region. There have been numerous attempts across the globe, which have tried to find methods to study, predict and mitigate the road traffic noise levels [1], [2], [9].

METHODOLOGY

Overview

The proposed approach for predicting the traffic noise level time history near roadways and tramways is similar in structure to other dynamic traffic noise prediction models [2]–[4], and consists of coupling a microscopic road traffic simulation model with a model for instantaneous vehicle noise emission and a point-to-point sound propagation model. A general overview of the model is shown in (1).

Estimation of Vehicle Noise

The traffic noise is composed of many individual vehicle noise sources. The individual vehicle noise, at the micro level, can be attributed to its components, which can be classified into: the engine noise, exhaust noise, transmission, type of road, aerodynamics.

Apart from the individual vehicle noise, the different variables which contribute significantly to the overall level of traffic noise include: traffic volume (number of vehicles on the road per unit time), traffic speed (average speed of vehicles on the considered road section), traffic composition (different types of vehicles present, like cars, buses, trucks, two-wheelers), gradients of the road (slope) and pavement surface. There are studies where the effects of vehicle horns [11] and acceleration/deceleration due to interrupted traffic flow conditions[1], [2] have also been considered.

The traffic noise levels at a particular location is assessed by using different descriptors. These descriptors are used to capture the time varying nature of traffic noise, because of short-term and long-term fluctuations in the noise level. Leq and L10 are the commonly used descriptors in traffic noise assessment and abatement [1], [2].

L10 denotes the noise level exceeded 10 percent of the time during the measurement period, usually the noisiest hour of the day. Leq denotes the constant average of sound pressure levels that contains the same amount of acoustic energy as the fluctuating levels of noise during the measurement period. Leq has been very frequently used as a standard descriptor to evaluate noise near urban roads, highways, residential and commercial areas.

The equivalent continuous sound pressure level [1], [2], Leq is given by

$$L\,eq = 1\log\left[\frac{P_{rms}^{\;2}}{P_{ref}^{\;2}}\right] = 10\,\log\frac{1}{T}\int_{0}^{T}10^{L(t)/10}\,dt$$
$$= 10\,\log\sum_{i=1}^{N}10^{Li/10} \qquad (1)$$

Where

p = A - weighted instantaneous acoustic pressure

P_{ref} = reference acoustic pressure = 20 (µ Pa)

The averaging time T can be one minute, one hour, one day and so on. The sound pressure levels Li can be aggregated and the overall level obtained for a particular period using Eq. (1). "A" weighting filter [6] is generally used to process the sound pressure level. Though L10 is easy for people to understand, Leq is considered more useful and relevant, and is internationally accepted for most of the traffic noise analyses. In addition, it can be used for, summing up, noise levels of different sources, and then included in the analyses. Leq is generally 3 dB (A) less than L10 for same traffic conditions.

Some other noise descriptors include the L90 (the background noise level), L50 and Ldn (day night average sound level).

In the present work, the variables, traffic volume (Q), number count of heavy and light vehicles (p) and average speed of vehicles (V), junction speed, have been considered using the traffic noise prediction model, as these variables are known to significantly contribute to the overall traffic noise level, as also confirmed by the variable importance study, described later. Experimental data sets of these variables and the equivalent continuous sound pressure level (Leq), have been extracted from the different traffic noise studies on 14 sites in July 2016. The locations have straight and flat roads. The sound pressure level (Leq) has been measured using a sound level meter how is an acoustic measuring instrument with the main features of a conventional sound level meter and integrator averaging, storage analyzers, NF EN 61672 class 1, tested and calibrated. The average speed of the vehicles has been obtained by using videography. A fixed distance (10 m) was marked on the road and the time taken by a vehicle to cover this distance was noted from the video. Thus, the speed was calculated for 3 vehicles and then the average was taken.

The considered variables, their description and a sample data set of a few values taken randomly are shown in section "case study".

DATA SET AND VARIABLES

All Investigations have agreed to introduce the LAeq over time as the most important indicator (more than the instantaneous noise level or the number of events) to describe the discomfort caused by roads, rail and tramway. Both indicators LAeq (7 am-10 pm) and LAeq (10 pm-7 am) can be considered equivalent if the difference between day and night indicates a lull of 5 dB (A).

The study includes the following acoustic indicators:

LAeq, LCpk, LCeq and LAn. In correspondence with international standards, the sizes typically used for a comprehensive study of the sound environment.

LAeq: Accumulation of noise over a long period.

The first negative effect is symbolized by the acoustic size LAeq (or Leq weighted decibels "A"). It expresses the accumulation of relatively low noise levels over a long period. The latter must not exceed 85 dB(A).

LCpk: instantaneous noise levels.

The second negative effect is symbolized by the acoustic size LCpk (or Peak weighted decibel "C").

It describes the extreme noise levels measured in time units can cause immediate damage to hearing.
The size LCpk must not to exceed 135 dB (C).

LCpk (Peak): the largest absolute value of the instantaneous noise pressure weighted C from the beginning of the measure in decibels.

LAn: noise levels exceeded for N% of the total measurement time.
L01 - L10 - L50 - L90 - L95:

These are the clues fractils reference used in environmental studies.

The main sources on a road and tram are:

- Units of ventilation and air conditioning
- Converters, choppers or for traction motors
- Auxiliary Equipment
- Sources of the movement: rolling noise (due to wheel/rail contact), traction motor and gearbox.
- Rolling noise
- Aerodynamics
- Friction

Other special noises can be recognized:

- The crunch: This problem appears mainly in low bend radius areas. A high-pitched noise is generated. Residents are generally very sensitive to this noise.
- The horn: it is used to release the tram tracks. No evidence has been found about it.
- Channel Devices: the noise impact may be high-level crossings. Such noise is part of the rolling noise. Because the sounds are much localized, we still list it as such noise particular.
- Contact catenary/pantograph, which often leads to an electric arc.

These particular noises, even if they can be annoying for residents, do not change much regulatory noise levels.

The usual speeds (greater than 15-20 km/h); rolling noise can be considered dominant. Some recent measures could counteract this statement: other sources remain important even beyond 20 km/h. Having no more specific evidence on this, we limit ourselves to the rolling noise modeling.

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COMPUTING MODEL

Orbis gis

OrbisGIS is a Geographic Information System oriented to scientific modeling. He wants a unified platform to create, process, edit, and share geographic vector data.

The Orbis Geographic Information System fits into the broader context of the implementation of a Spatial Data Infrastructure Urban. It is one of the essential components for handling space data (create, update, processing, modeling).

Built on the basis of proven open-source technologies such as the library of operators and spatial predicates Java Topology Suite or the bookstore Image J, OrbisGIS allows to cross and visualize 2D as well as vector data from databases or flat files as raster images. [12]- [15].

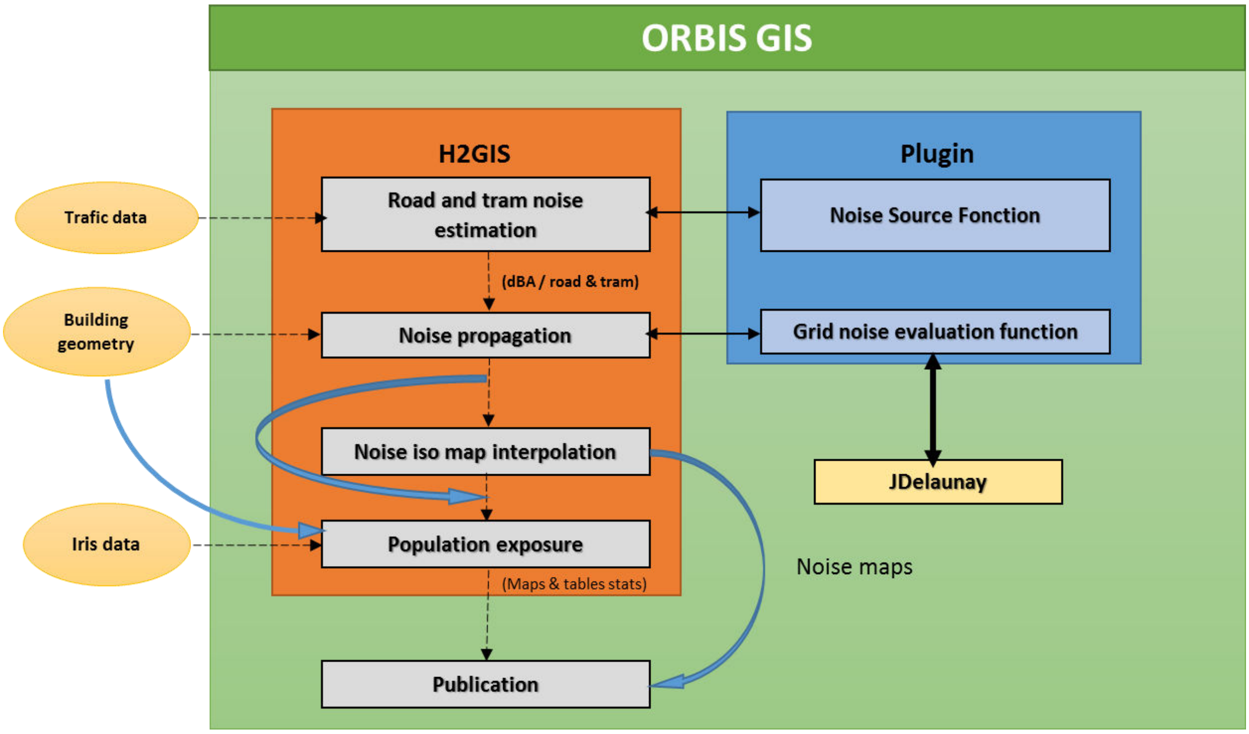

Figure-1. The architecture of the OrbisGIS software and Noise map plugin [12.]

Noise map

Noise map is the plugin of OrbisGIS can produce noise maps at the scale of an agglomeration, from data “built” and traffic data (Figure-1).

The new algorithms used to establish the noise map of an urban area with a similar accuracy than traditional algorithms.

The calculations are made according to a simplified procedure for the French regulatory method [5], and can take into account noise sources from road transportation (light vehicles, heavy vehicles) and rail (tram only).

The calculation method is based on a 2D simplification of the regulatory French method “NMPB 2008,” adopted in the framework of the European Directive 2002/49/EC relating to the assessment and management of environmental noise.

Acoustic emission is based on the guide Sétra “Forecast of road noise. Calculation of noise emissions from road transport. “The model has been simplified for the consideration of the “dynamics” of vehicle traffic, the nature and age of road surfaces.

From a practical point of view, the flow of traffic is considered as a series of point noise sources equivalent, each source being defined by an acoustic emission spectrum, especially depending on the speed flow of road traffic, slope road, the type and age of road surfaces, as well as a vehicle reference spectrum considered.

Acoustic propagation is considered taking into account the acoustic reflection on the ground (assumed to be perfectly flat and reflective), the acoustic reflection on the facades of buildings (specular reflection with low acoustic absorption) and the acoustic diffraction on the vertical edges buildings.

Acoustic calculations are performed either for observation points in building facade (for noise exposure calculations) or to a network of points achieved by constructing a mesh by Delaunay triangulation of the study area, with near-refinement lanes and buildings.

The program is usually expressed in the form of point sources equivalent to either a vehicle or a traffic flow. Representation “point source” is well suited for engineering tools based on either the source-image method or the ray shooting method.

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These approaches are then used to calculate the attenuation of sound between two points, taking into account the infrastructure, soil, meteorology, buildings, and congestion formed by vehicles and urban architecture.
In this approach we have initiated, an equivalent source is characterized by a position relative to the roadway, an acoustic power in decibels (power level Leq), a dependency of the cinematic function of the vehicle (speed), a spectrum, and directivity in space.
In our study we are considered:

- For motorized two-wheelers, we believe that this type of source does not contribute significantly to the overall noise produced by transport.

- For the tram, an emission law is retained depending on the speed by choosing different pairs of parameters (we will see later) to take into account the grassy soil or rigid encountered in the agglomeration of the city of Rabat.

- For handling, the directivity of the sources is not taken into account.

Initially, because of the extent of the calculation area (i.e. agglomeration), decomposition into sub-area is formed. Each sub-area results in a fine and adaptive mesh to build the calculation point's network (receptor points), while ensuring continuity between sub-areas and refinement near the traffic lanes.

Secondly, a "Maps" noise emission is built for each calculation point, as an array of point sources. The methodology is based on the decomposition of source lines (traffic flow) in point sources, whose characteristics are defined from the information produced by the traffic model, with some simplifications for restarting sections, light vehicles and the distribution between heavy and light car traffic on the various hourly periods [13]-[15].

The third part of the method consists in calculating the acoustic propagation from point sources to an observation point. The total sound field at a calculation point is then obtained by summing the individual contributions of the direct sound reflected on the facades and the diffracted field. In our approach, the propagation is considered in two dimensions (2D), by positioning each source close to the ground, and receivers in the same horizontal plane as the source.

Each direction (direct, reflected and diffracted) being the bearer of a clean acoustic energy (according to the propagation distance, the sound absorption coefficient of the facades, the frequency of the sound wave), the sound level at each point of observation is calculated by summing the contributions of all trips.

This allows obtaining a sound level for each observation point for traffic data set corresponding to a time interval. Finally, noise maps obtained for each sub-area, used to have a general idea about the level of noise pollution along the study area considered in the study.

CASE STUDY

In our case study, we tested the modeling of the noise impact of road and tram traffic in the Agdal district, by the model "Noisemap,' and compare it with specific measures in principal streets of the district.

The map below (Figure-2) is the result of the digitization of the different sources of noise pollution, and studied receptors.

Buildings:	Polygon
Roads:	Polyline
Tram way:	Polyline
Forest and green space:	Polygon

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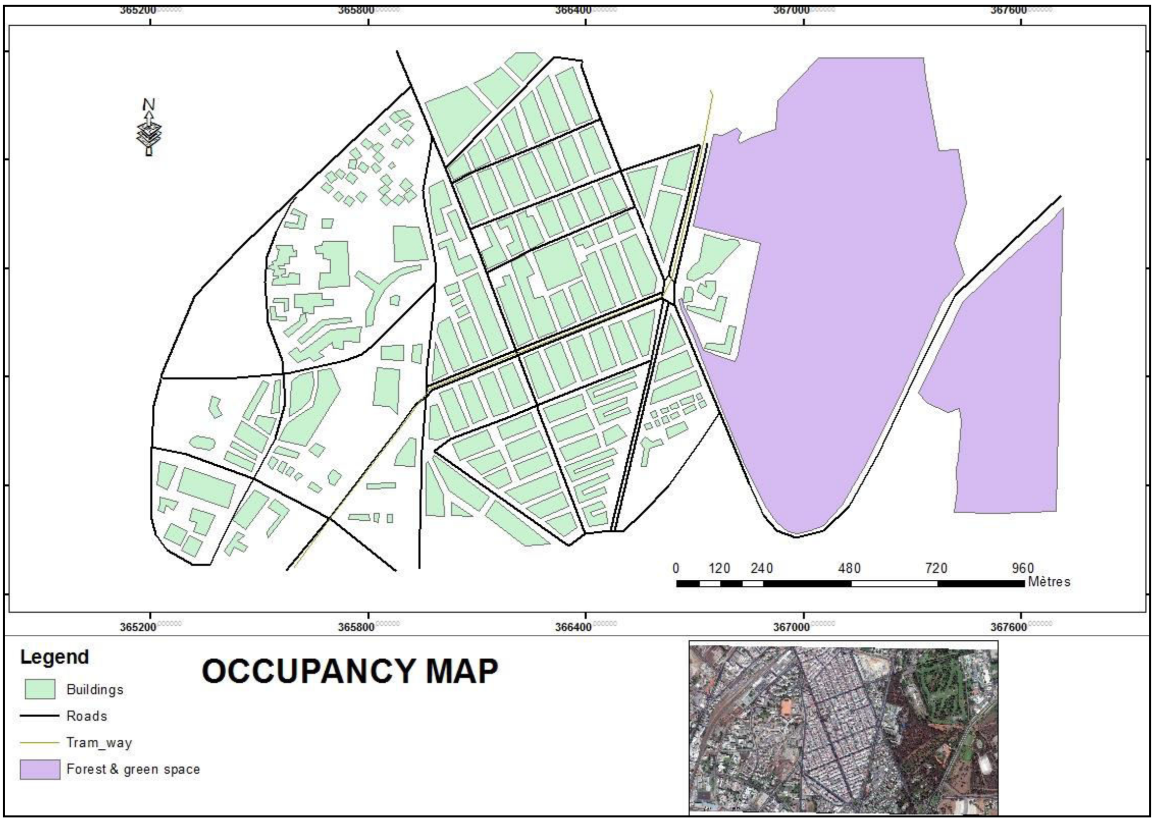

Figure-2. Maps of roads and buildings in the study area.

Figure-3. Field works.

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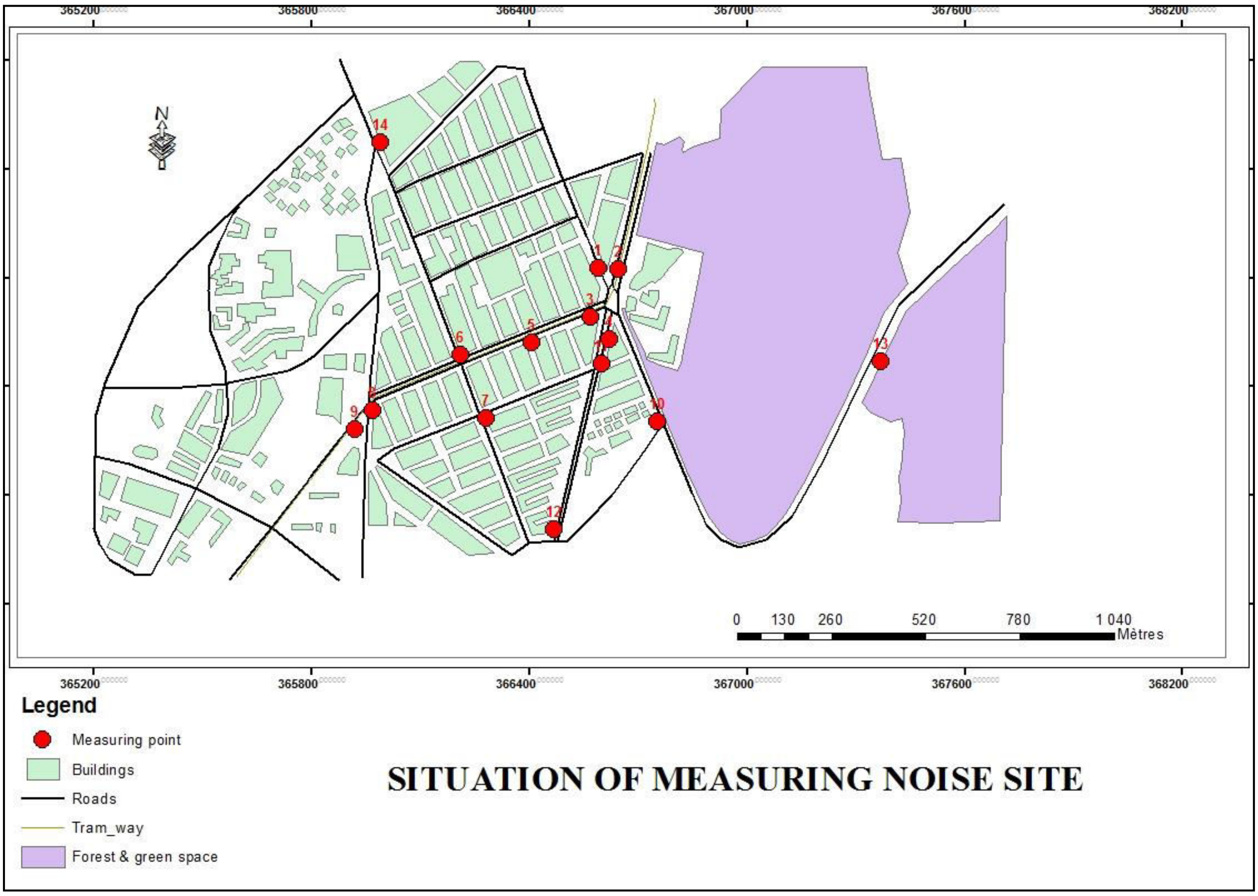

Figure-4. Situation of measuring noise site.

The measures were conducted for 24 hours, and the Table below presents the noise levels and the important fractils indexs

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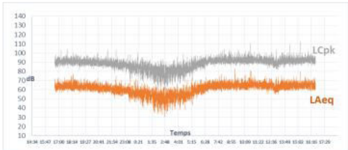
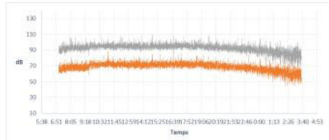
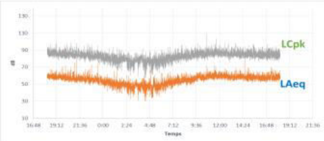
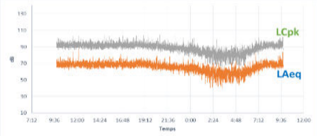
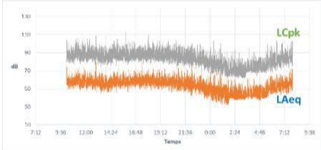
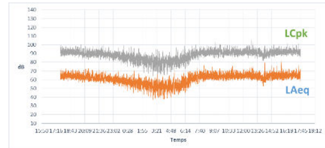
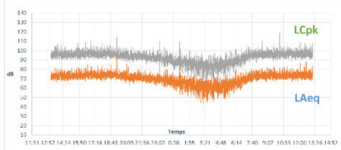
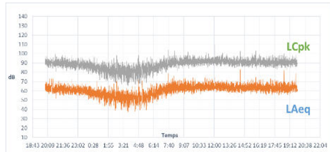
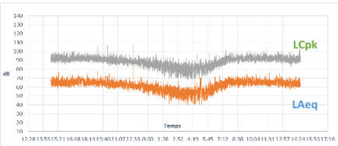
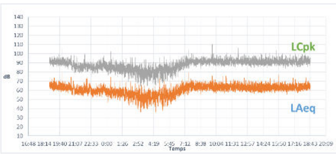
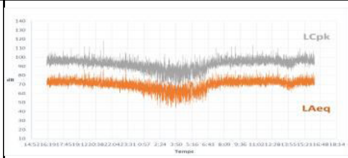
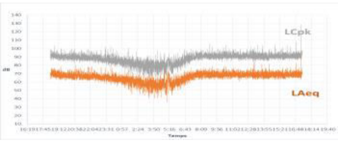
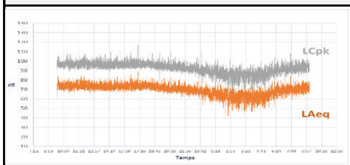
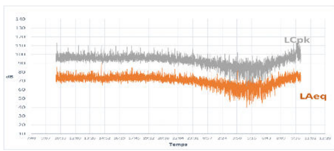
Site N°1		Site N°2		Site N°3	
					
LAeq: 63,5 dB(A)	L10= 67,3 dB(A)	LAeq: 69,8 dB(A)	L10= 74,2 dB(A)	LAeq: 56,2 dB(A)	L10= 60,4 dB(A)
	L50= 61,9 dB(A)		L50= 69,4 dB(A)		L50= 55,7 dB(A)
LCeq: 77,8dB(A)	L90= 53,2 dB(A)	LCeq: 80,7 dB(A)	L90= 62,4 dB(A)	LCeq: 71,8 dB(A)	L90= 47,1 dB(A)
Site N°4		Site N°5		Site N°6	
					
LAeq: 68,2 dB(A)	L10= 71,1 dB(A)	LAeq: 58,3 dB(A)	L10= 61,8 dB(A)	LAeq: 63,4 dB(A)	L10= 68,8 dB(A)
	L50= 66,1 dB(A)		L50= 53,9 dB(A)		L50= 61,5 dB(A)
LCeq: 77,6 dB(A)	L90= 57,4 dB(A)	LCeq: 73,5 dB(A)	L90= 40,8 dB(A)	LCeq: 77,5 dB(A)	L90= 52,7 dB(A)
Site N°7		Site N°8		Site N°9	
					
LAeq: 73,2 dB(A)	L10= 76,2 dB(A)	LAeq: 63,1 dB(A)	L10= 66,4 dB(A)	LAeq: 64,1 dB(A)	L10= 67,5 dB(A)
	L50= 71,2 dB(A)		L50= 61 dB(A)		L50= 62,5 dB(A)
LCeq: 81,7 dB(A)	L90= 62 dB(A)	LCeq: 77,5 dB(A)	L90= 52,9 dB(A)	LCeq: 77,7 dB(A)	L90= 53,9 dB(A)
Site N°10		Site N°11		Site N°12	
					
LAeq: 62,9 dB(A)	L10= 66,3 dB(A)	LAeq: 71,4 dB(A)	L10= 75,2 dB(A)	LAeq: 68,3 dB(A)	L10= 71,5 dB(A)
	L50= 61,2 dB(A)		L50= 69,8 dB(A)		L50= 66,6 dB(A)
LCeq: 77,5 dB(A)	L90= 53,5 dB(A)	LCeq: 81,1 dB(A)	L90= 61,9 dB(A)	LCeq: 76,3 dB(A)	L90= 58,1 dB(A)
Site N°13		Site N°14			
					
LAeq: 69 dB(A)	L10= 75,8 dB(A)	LAeq: 70,3 dB(A)	L10= 75,3 dB(A)		
	L50= 70,1 dB(A)		L50= 70,2 dB(A)		
LCeq: 80,8 dB(A)	L90= 61,8 dB(A)	LCeq: 81,7 dB(A)	L90= 61,6 dB(A)		

Figure-5. Noise levels and the important fractils indexs.

We pushed the analysis with LDB23 software to determine the noise of the day and the noise at night. The table below shows the results of the analysis in LAeq day and LAeq night.

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Table-1. Results of the analysis in LAeq day and LAeq night.

Landmark	Locality	Noise level measured during LAeq [7am – 10pm] and LAeq[10pm-7am]		Lull day/Night dB(A)
		LAeq day	LAeq night	
1	Omar ibn khattab Street	65,4	59,7	5,7
2	United Nations tram station	72,2	66,4	5,8
3	French Street - Libyan school	59,2	53,6	5,6
4	United Nations Street	69,8	63,6	6,2
5	French Street - Ouargha Street	60,2	53,3	6,9
6	French Street - Fal ould oumeir Street	65,2	58,8	6,4
7	Fal ould omeir Street - Atlas Street	74,7	68,3	6,4
8	French Street - Ibn Sina Street	64,7	58,8	5,9
9	Maa al aynayne Street	66	59,8	6,2
10	Omar ibn khattab Street - Abou hanifa Street	64,4	59,2	5,2
11	Atlas Street - United Nations Street	74	68,6	5,4
12	United Nations Street	70	64,6	5,4
13	Imam Malik Street	74	67,6	6,4
14	Fal ould omeir Street - Ibn sina Street	74,4	68,4	6

In order to simulate the propagation of noise in the study area, we integrated the data traffic on the roads database, in order to launch the spatial modeling using GIS software “OrbisGIS” and the plugin “noise map.”

The graphs below show the number of light and heavy vehicles crossing the roads in the counting period.

This indicates that light vehicles are important in the main roads where parking areas are arranged; therefore, it is low at the streets where parking is badly managed, and considerably reducing the circulation of light vehicles.

Heavy vehicles predominantly for the supply, through the roads that lead to the shops and restaurants and are generally frequented the beginning of the day and late at night to avoid being stuck in traffic jams.

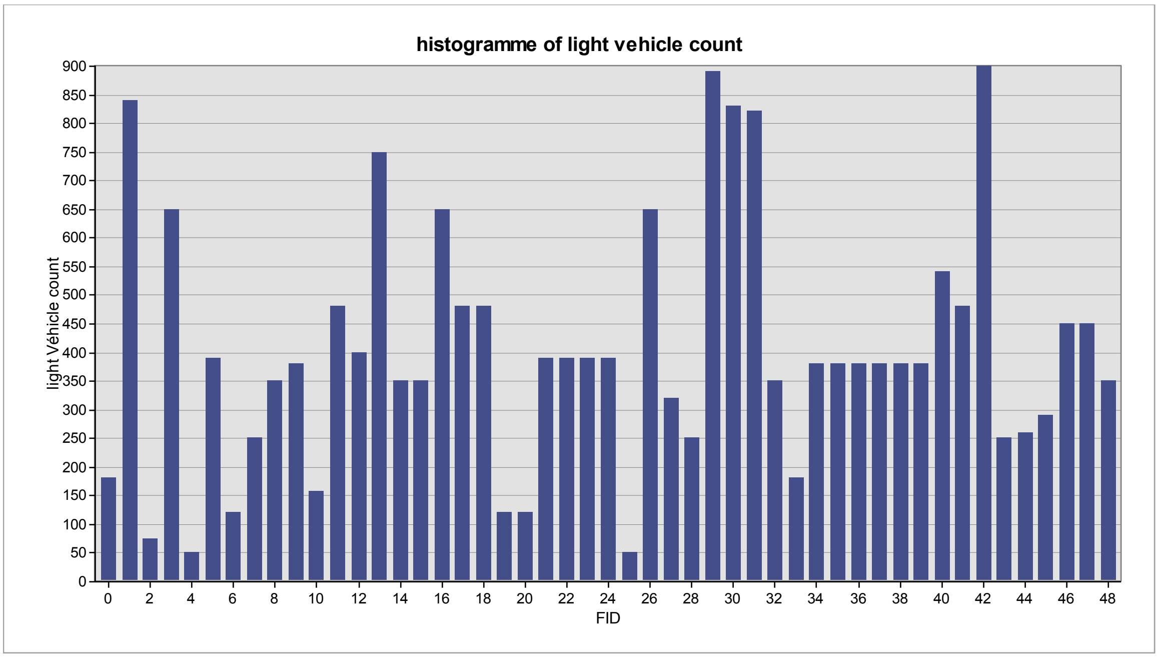

Figure-6. Histogram of the number of light vehicles.

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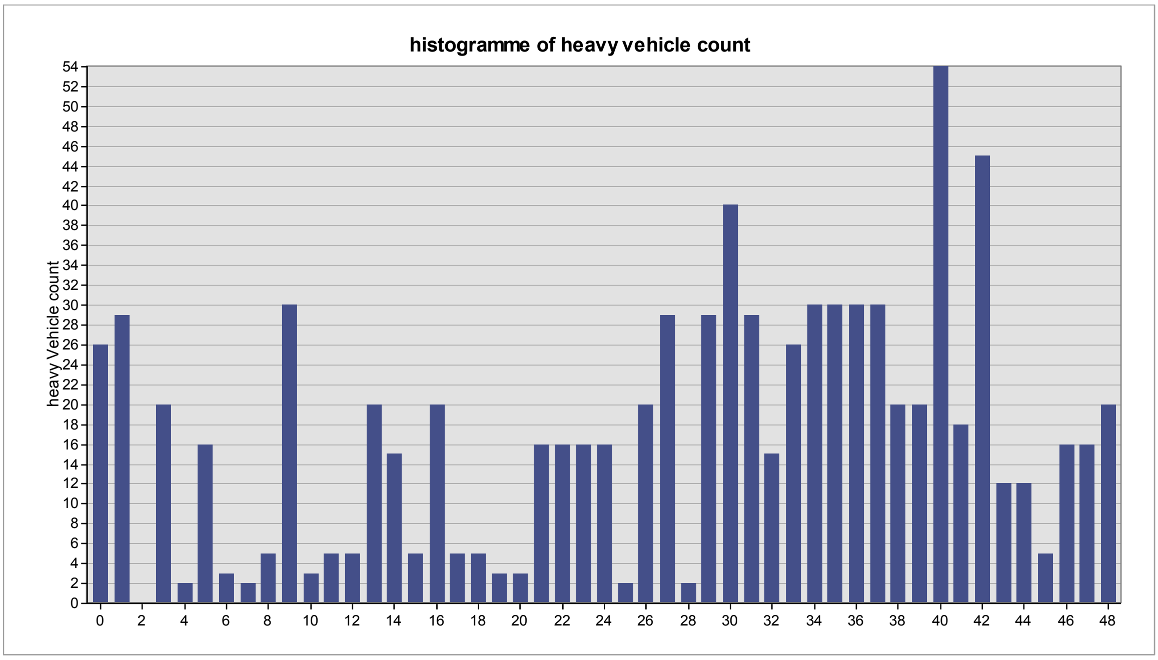

Figure-7. Histogram of the number of heavy vehicles.

For the tramway databases, the main data that were included are shown in the table below:

Parameters	value
Load speed	29 km/h
Number of passes per hour	10
Ground type	=0
Anti vibration system	yes

DISCUSSIONS

Daytime noise levels (LAeq 7 am-10 pm) are between 59.2 and 74.7 dB (A) while the night noise levels (LAeq 10 pm-7 am) between 53.3 and 68.6 dB (A).

The highest noise levels relate to measurements made at the UN streets, and the Fal Ould Omeir Street for diurnal measures and the Ibn Sina Street for night measures.

Regarding lulls day/night (difference between LAeq [7 am-10 pm] and LAeq [10pm-7am]), all measured values are greater than 5 dB, which explains the impact of road traffic during the whole day and continued overnight. After the stop of tram traffic at 11 pm, measurements recorded at the Street de France, shows a noise level L90 = 41.1 dB (A) at the station No. 5, represented by the fractil index 90.

Are summarized in the table below, firstly the results at the measuring points, and secondly the results of our modeling.

Table-2. The real and simulated results in each measuring points.

Landmark	Locality	Noise level dB(A)		Gap in decibels
		Real noise measure	simulated result by noise map	
1	Omar ibn khattab street	63,5	62,4	1,1
2	Nations unies tram station	69,8	64,1	5,7
3	French Street_ lybian school	56,2	55,2	1
4	United Nations Street	68,2	66,9	1,3
5	French Street - Ouargha Street	58,3	56,8	1,5
6	French Street - Fal ould oumeir Street	63,4	62	1,4
7	Fal ould omeir Street - atlas Street	73,2	69,8	3,4
8	French Street - ibn sina Street	63,1	61,3	1,8
9	Maa al aynayne Street	64,1	63,9	0,2
10	Omar ibn khattab Street - abou hanifa Street	62,9	61,4	1,5
11	Atlas Street - United Nations Street	71,4	69,2	2,2
12	United Nations Street	68,3	67,8	0,5
13	Imam Malik Street	69	59	10
14	Fal ould omeir Street - Ibn sina Street	70,3	69,7	0,6

The results obtained during the modeling, not differs too real results + or-3.4 dB (A), a share in two situations, firstly at the station 2, the difference is 5.7 dB (A). This situation can be justified by the presence of a traffic light during work and which generate an occasional traffic jam is consequent we had heavy traffic with a state of stress that cause emission of car horns. The other point of difference is the point 13 with 10 dB (A) of gap, which can be justified by a traffic jam also in both directions, mainly caused by the construction works of the new bypass road between Rabat and salé city.

Decibels are logarithmic units. They add up when the quantities are increasing.

It is often necessary to calculate the level resulting from the mixing of two independent sources.
The addition is necessary when the systems are linear, but we must add the variables, not their logarithm.

When the sources are independent, we have to make the sum of their powers. When we have two levels L1 and L2 of signals, the resulting level from mixing the two signals is estimated by (2):

$$L = 10\log\left(10^{\frac{L1}{10}} + 10^{\frac{L2}{10}}\right) \quad (2)$$

When passing at the Streets (United Nations, French, and Imam Malik) simulation of noise generated by the tram is in the order of: 68.6388 dB (A):

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Table-3. Simulated data of the road and tram traffic in study area.

Locality	Road traffic noise simulated dB(A)	Tramway traffic noise simulated dB(A)	General noise traffic dB(A)
Omar ibn khattab Street	62,4	No tram line	62,4
United Nations tram station	64,1	68,6388	69,9
French Street _ lybian school	55,2	No tram line	55,2
United Nations Street	66,9	No tram line	66,9
French Street - Ouargha Street	56,8	68,6388	68,9
French Street - Fal ould oumeir Street	62	68,6388	69,5
Fal ould oumeir Street - Atlas Street	69,8	No tram line	69,8
French Street - ibn sina Street	61,3	68,6388	69,3
Maa al aynayne Street	63,9	68,6388	69,9
Omar ibn khattab Street - abou hanifa Street	61,4	No tram line	61,4
Atlas Street - United Nations Street	69,2	No tram line	69,2
United Nations Street	67,8	No tram line	67,8
Imam malik Street	59	No tram line	59
Fal ould omeir Street - Ibn sina Street	69,7	No tram line	69,7

The graphical representation of Iso-levels is presented below:

Figure-8. The distribution of noise in the study area.

Is noted on this map that noisy areas are limited to main roads and road intersections. The passage of the tram does not generate excessive noise, as its overall noise does not exceed the noise generated by road and commercial activities nearby.

CONCLUSIONS

Through this work, we applied the noise map model to simulate the noise level of Agdal district, and we had compared the results obtained from the simulation and measurement results in sensitive places. A shift of about 2.3 dB (A) is tolerable, and we'll help to correct the error in other cases.

We'll conduct another test with the software Orbis Gis with its new version 5.1Molene, which allows the horizontal and vertical conducted analyzes of noise propagation. At this time we are currently collecting the elevation data of the building, so this will help us to simulate noise on the facades of buildings, and therefore assess its impact on the population living in different floors.

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