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# Effect of Urban Morphology on Road Noise Distribution

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***Abstract*: The present research conducted in the city of Biskra focuses on the relationship that can exists between urban morphology and road noise distribution. Ten community-housing areas have been investigated in order to evaluate their noise scape, using noise mapping method. The connection between the morphological characteristics and road noise distribution using Pearson correlation tests, showed a strong relationship between the two. The results of this research indicate that the urban morphology has a significant impact on the noise scape. Acoustic environment at urban scale represents therefore an important challenge for the urban designers and planners at early design stage for a sustainable and healthy urban environment.**

***Keywords*: Urban Morphology**

## 1. Introduction

Noise is the set of sounds that can cause a sense of discomfort and stress [1], it has become among the characteristics of modern life especially in urban areas. Because of its detrimental effects on our planet, our quality of life and our acoustic comfort, it has been classified since the seventies as an environmental pollutant [2] by the United States environmental protection agency.

This problem has become more evident in recent years, according to the WHO. More than 44% of European population are regularly exposed to noise levels that exceed 55 dB, a level that threatens human health [3] because it can cause sleep disturbances and cardiovascular and even mental pathologies.

## 2. Methodology

This work is structured into three parts: the first concerns the selection and analysis of urban morphologies. Then a primary evaluation of each configuration is set up in the second part using noise prediction software. In the last part Pearson correlations Testes were performed using SPSS statistical software to define the relation may exist between the noise scape and the urban fabric.

## 3. Cases study

Existing urban configurations (collective residential area) were selected in this study according to morphological criteria such as height of the buildings, width of the streets, urban geometry and building fabric composition. The majorities of the chosen morphologies were built in the 1980s, with two main representative layouts; linear configurations (700 district, HLM city, 200 district) and centralized configurations (748 district, Saada city, belaiat1). The configurations chosen are shown in Fig. 1 and Table 1.

Fig. 1. Location of the selected samples (Source internet: Google earth)

Ten urban areas were chosen, based on satellite images, in situ visits, morphological and traffic criteria.

## 4. Characterization of urban morphologies

The urban entities of the city are the result of historical events, laws, regulations and technological development, what makes the analysis of urban morphologies a difficult task [10]. This is why we have opted for the quantitative characterization of morphological indicators (measuring urban morphology), which is an indispensable element in studies aimed to understand the relationship between the urban form and different environmental factors such as day lighting, thermal, olfactory, or acoustic comfort as the case of this research. Because it will allow us to better

characterize our configurations and extract additional information that may help us to analyze these correlations.


Fig. 2. Illustration of report between empty surface and total surface (Porosity) (Source: Huang J and all)

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In this research, three main indicators have been selected:

- *Porosity (ROS):* is the permeability of the urban form, the ratio of the empty surface on the total surface
- *Compactness:* One of the main characteristics of a sustainable city, this indicator is calculated using the following formula: Urban Compactness (absolute) = Σ Volume frame / Σ urban area.
- *The density:* the built density is the ratio of the sum of the built area on total area.

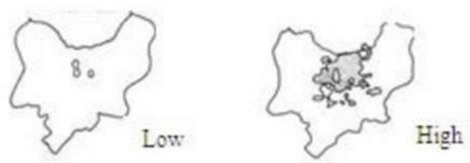



Fig. 3. Illustration of report between constructed area and total area (density), (Source: Oliveira M.)

Table 1
Quantitative indicators of each neighborhood

| Name of district | Code Porosity | Total surface m² | The density | Compactness | Porosity |
|---|---|---|---|---|---|
| 748 | 1 | 29988,37 | 36.89 | 5.27 | 63.12 |
| 500 | 2 | 19372,88 | 21.15 | 3.03 | 78.37 |
| 200 | 3 | 35214,64 | 39.01 | 5.64 | 60.99 |
| Rue Batna | 4 | 19372,88 | 34.04 | 6.52 | 65.96 |
| Belaiat 1 | 5 | 10671,94 | 27.76 | 4.16 | 72.24 |
| Belaiat 2 | 6 | 7080,04 | 33.69 | 4.88 | 66.31 |
| Hlm2 | 7 | 8076.3 | 28.09 | 3.93 | 71.91 |
| Hlm1 | 8 | 11349.16 | 16.49 | 2.47 | 83.5 |
| Rue Chetma | 9 | 84111.94 | 26.86 | 4.03 | 73.14 |
| Cité Saada 2 | 10 | 10218,87 | 31.81 | 4.77 | 68.19 |

## 5. The noise mapping

### A. *Urban fabrics (Data Acquisition)*

- In addition to in-situ visits, the master urban development plan of Biskra (PDAU) and satellite images have been used to collect physical data of the urban fabric such as height and spacing between buildings, the dimensioning of the streets, the type of soil and paving and the presence of vegetation.

### B. *Urban traffic*

- The same level of urban traffic is established for all urban configurations.

Table 2
Traffic level

| type | Number / hour | Max speed km/h |
|---|---|---|
| cars | 400 | 50 km/h |
| heavyweights | 130 | 30 km/h |

### C. *Calculation of the noise maps*

The TYMPAN CODE software [20] which is mainly based on methods of calculations ISO 9613 [21] and NMPB [22, 23], was used to calculate the noise maps.

The calculation parameters used for all urban morphologies in this study are presented in Table 4:

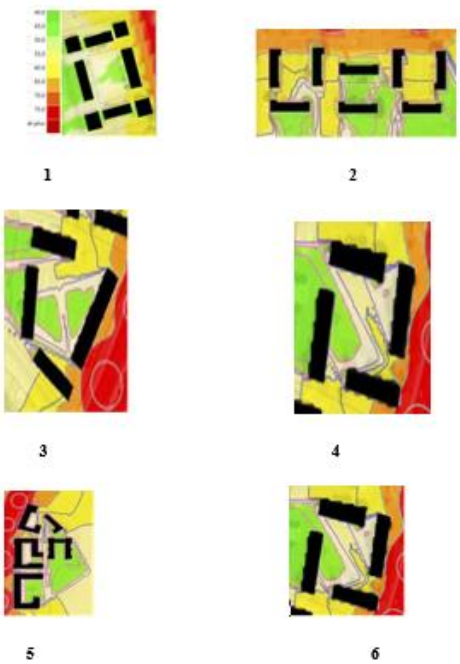
Table 3
The calculation parameters

| Temperature | Relative humidity | Atmospheric pressure |
|---|---|---|
| 20c | 70% | 101325.00 Pa |

The resistance of the soil, the presence of vegetation, weather conditions and the presence of screens is taken into account during the calculations. Results in table 6.

## 6. Analysis of results

Table 4
Noise maps




### A. *The effect of urban morphology on the distribution of road noise*

In this study, the analysis of noise maps is based on the percentage of exhibition (Zones of exhibition). Each noise map was divided into three zones A, B, C according to the intensity of noise, see table 6.

Table 5
Classification of zones

| $L_{day}$ dB (A) | classification |
|---|---|
| Zone | |
| Zone A > 50 | low exposure - acceptable |
| Zone B 65_50 | Intermediate |
| Zone C > 65 dB | Overexposed - unacceptable |

The result of the calculations of the percentage of exhibition for the ten quarters relative to the total space outside surface (without the frame) is in Table 7

It is clear from table 8 and histogram 1 that the distribution of road noise depends on urban form and that there is a strong relationship between urban fabric and road noise scape. It is interesting to note that the most protected areas in these case studies are: the neighborhood n 3 (fig. 4) with a percentage of protected areas exceeding 75%, then the neighborhood n4 with a percentage of zone A greater than 53%. The most exposed neighborhoods are the neighborhood n2, n7 and n10 with a percentage of Zone C between 14 and 23% of outdoor space surface.

Table 6
Percentage of exposure by zones

| neighborhood | Zone A % | Zone B % | Zone C % |
|---|---|---|---|
| (1) | 43.53 | 50.1 | 6.37 |
| (2) | 24.61 | 55.99 | 19.40 |
| (3) | 78.10 | 24,37 | 3.26 |
| (4) | 55.53 | 30.75 | 13.72 |
| (5) | 41.26 | 43.92 | 14.82 |
| (6) | 46.65 | 36.63 | 13.72 |
| (7) | 42.05 | 41.63 | 16.32 |
| (8) | 14.49 | 66.63 | 18.88 |
| (9) | 24.28 | 58.27 | 17.45 |
| (10) | 58.87 | 17.64 | 23.49 |

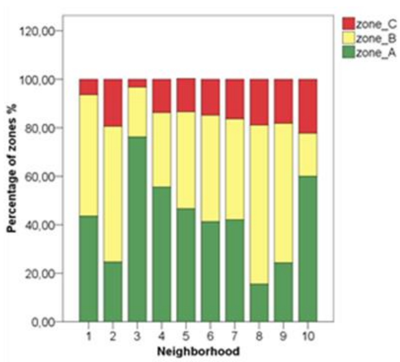



Fig. 4. Percentage of exposure by zone

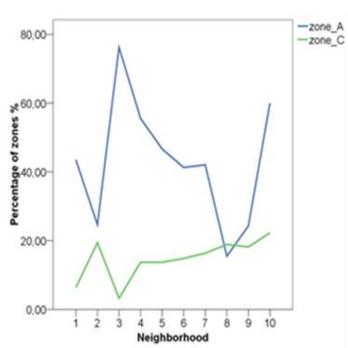



Fig. 5. Percentages of area A and C in each neighborhood

*B. The correlation between the indices of the urban morphology and noisescape*

To define the relationship between quantitative indicators of urban fabric and distribution of road noise, Pearson correlations Testes were performed using SPSS statistical software, results shown in Table 7.

Table 7
Pearson correlation test result

| Pearson zone Correlation | | porosity | density | compactness |
|---|---|---|---|---|
| Zone A | Pearson Correlation | -,832(**) | ,765(**) | ,727(*) |
| | Sig. (2-tailed) | ,003 | ,010 | ,017 |
| | N | 10 | 10 | 10 |
| Zone C | Pearson Correlation | ,800(**) | -,855(**) | -,707(*) |
| | Sig. (2-tailed) | ,005 | ,002 | ,022 |
| | N | 10 | 10 | 10 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

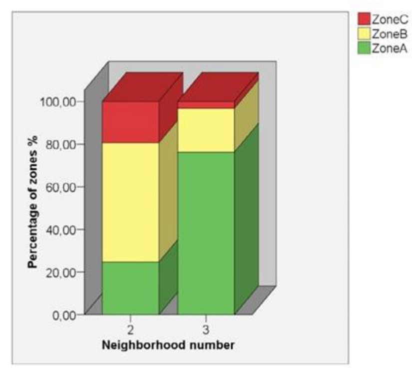



Fig. 6. Percentage of exposure zoning for neighborhood 500 and 200 lot

## 7. Results analysis

It is clear that the change in the distribution of road noise and the percentage of zones A and C are mainly linked to the physical indicators of urban fabric.

It is observed that, as porosity increases the surface of the zone C increases too and the surface of the Zone A decreases. This is due to the increase in the permeability of the urban fabric presented by the vacuum between the buildings that act as sound pipes, which allows the penetration of a large amount of sound rays that will deepen in the urban fabric.

The density is the ratio of the built on the total area, more the density is high more the presence of obstacles in the urban environment is important, the result of these obstacles are the shadow areas (protected areas), which explains the increasing linear relationship between density and Zone A. The growth of the density will reduce the surface of the overexposed area Zone C, and increase the surface of the protected area zone A. Compactness allows us to define the density of buildings in three dimensions, it is clear that the effect of compactness on the distribution of road noise is similar to that of urban density. More the compactness is high more the presence of obstacles in the urban area is important, the result is the increase of protected areas (zone A) and the reduction of overexposed areas (zone C).

## 8. Conclusion

The existence and the importance of the relationship between physical indicators of urban morphologies and noisescape are evident. Urban morphology can play a key role in the quality and nature of our sound environment, so it is important to take into account the distribution of road noise in the urban fabric before the planning of the outdoor spaces and even the organization of the interior spaces of the accommodations. It is important to note that this study has strengthened the ranking of urban compactness as one of the fundamental characteristics of a sustainable city, because of the strong increasing linear relationship that links between protected areas and urban compactness. The use of outdoor noise prediction software in the initial design phase is indispensable as it can help designers to have urban morphologies with acceptable and controlled noise exposure

## References

[1] Tallal Abdel Karim Bouzir, Noureddine Zemmouri, Effect of urban morphology on road noise distribution, Energy Procedia, Volume 119, 2017, Pages 376-385.
[2] Impact of morphology on climate.