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FUZZY SETS AND SCREENING DIAGRAM

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1. INTRODUCTION

A possible consequence of governmental actions or of the execution of public and private projects, is the modification of the environment like the alteration of the noise and vibration context in an urban area.

The introduction of a new urban activity can also promote an alteration of the land use, increasing or decreasing the existing facility in the neighbourhood, and modifying the local population dynamic, changing continuously the environmental impact some times on interval of 20 years.

Screening Diagram

A screening diagram (Fig. 1.) is used by governmental agencies to represent the environmental noise impact caused by the introduction of a new activity in urban area [1]. This diagram proposes a representation of a determinate situation in a co-ordinate system where the noise level produced by a new activity (NLNA) is represented as a function of the background noise level (BNL) existing before the introduction of this activity. Two different conditions are considered to verify if it exists or not environmental noise impact. The first condition is related to the noise background changed due to the introduction of the activity and the second is related with a level criterion (NLC) that cannot be exceeded by the level NLNA. Using classical results about decibels "addition", four regions are defined:

	$y \leq x\text{-}10$ OR $x \oplus y \cong x$	$y > x\text{-}10$ OR $x \oplus y > x$
$y \leq y_c$	region 1	region 2
$y > y_c$	region 3	region 4

Table 1. *Initial partition of the case. y = NLNA, x= BNL, y_c= NLC and $\oplus$ is the symbol for logarithmic addition.*

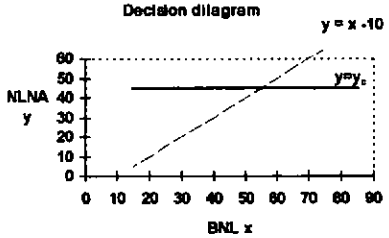

Fig. 1. Screening Diagram.

For practical purpose, it is helpful to define two number N_1 and N_2 to get a more flexible partition to be used by noise control practitioners.

	$y \leq x\text{-}10 + N_1$	$y > x\text{-}10 + N_1$
$y \leq y_c + N_2$	region 1	region 2
$y > y_c + N_2$	region 3	region 4

Table 2. Flexible partition.

The values of N_1 and N_2 can be provided from results about acoustic perception and annoyance. From table 3 [2] and table 4 [3] value for N_1 and N_2 can be near 3dB.

Change in intensity level in dB	Change in apparent loudness
1 dB	Almost imperceptible
3 dB	Just perceptible
5 dB	Clearly noticeable
10 dB	Twice (or one-half) as loud
18 dB	Very much louder (or quieter)

Table 3. Perception of the variations of sound.

In the Brazilian Standard NBR 10151, a Noise Level Criterion on the community response to noise is proposed, as shown in table 4.

NLNA - NLC IN dB(A)	Category of response	Description
0	No response	No observable reaction
5	Low	Sporadic complaints
10	Medium	General complaints
15	Vigorous	Community action
20	Very vigorous	Strong community action

Table 4. Community response to noise.

In the tables 3 and 4 it is shown that there exists a relation between the variation of noise levels in decibels and change in the perception of the loudness and in the response of the community. There is a relation between linguistic expressions and values. The values are obtained from inquires where the results depends on the type and the number of questions, the way of the information is concentrated in levels performing a partition of the universe of the possibilities.

2. FUZZY SCREENING DIAGRAM

Fuzzy Theory provides good framework than can be used to analyse the methodology used in social enquiries. After Zadeh "Our ability to make precise and yet significant statements about its behaviour (of humans) diminishes until a threshold is reached beyond precision and significance become almost mutually exclusive characteristics (...) It is in this sense that precise quantitative analysis of the behaviour of humanistic systems are not likely to have much relevance to the real word societal, political economic and other types of problems which involve humans either as individuals or in groups. The stream of information reaching the brain via the visual, auditory, tactile and others senses is eventually reduced to the trickle that is needed to perform a specified task with a minimal degree of precision" [4]. Some useful definitions of fuzzy theory are presented as linguistics variables, fuzzy sets, membership functions and fuzzy algorithms [5,6].

Fuzzy sets. According to Zadeh, "A fuzzy subset A is characterised by a membership function $\mu(x)$ which associates with each element x a number between 0 and 1 which represents the grade membership of x to the fuzzy set A". There is no sharp transition from membership to non membership.

Linguistics variable. Most of the classes in the human language or in the real world do not have crisp boundaries. For example, the class of ANNOYING NOISE LEVEL is not a crisp set but it is a fuzzy set, where for every level in dB(A) is associated a membership function between 0 and 1, 0 is used when the noise is not perceptible and 1 when it is. ANNOYING is a linguistic variable associated with this fuzzy set.

Hedges. There are words as very, highly, small, large, medium, unlikely... which modify the fuzzy set and the membership function.

It is interesting to observe that enquires asking if the noise is annoying are not successful but if it is asked if the noise is highly annoying the response is better.

Fuzzy algorithms. Fuzzy algorithms is an ordered sequence of instructions of conditional or unconditional statements containing labels of fuzzy sets. An example of statements:

Noise level is 50dB(A)
    Call Sleep DISTURBED; Call communication DIFFICULT
if sleep is DISTURBED then annoyance is INCREASED
if communication is DIFFICULT then annoyance is INCREASED

From these information it is important to observe that an analysis of the questions used in a social survey on noise annoyance, on the use of the response to establish noise limits can be performed using the concepts of fuzzy theory.

For example, the values for N1 and N2 proposed previously can be fuzzy sets with the membership function equal to 0 for N1 or N2 = 0 and membership function =1 for N1 or N2 =3dB(A). Between 0 and 3dB(A), the membership function if increasing from 0 to 1.

The fuzzy theory permit to transform the initial diagram to a set of diagrams that corresponds to a gradual perception change or a gradual annoyance change producing thus a fuzzy partition of the initial diagram allowing better decision making in noise control and in environmental noise impact studies.

3. CONCLUSION

The determination of noise limits for environmental noise is based mainly on the socio-psychological surveys providing vague or fuzzy results. Fuzzy theory can be used to aid people to prepare the epidemiological questionnaire surveys as well as to represent the results in a better form [7].

References

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