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AN ASSESSMENT OF OCCUPATIONAL NOISE EXPOSURE IN CONCRETE MIXER TRUCK DRIVERS

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Abstract. *This research characterized the exposure to occupational noise in a sample of 28 concrete mixer trucks drivers. Concrete mixer trucks are vehicles used daily at concrete batching plants. Data collection was carried out on drivers assigned to two concrete plants located in the city of Brasília-DF (Brazil): The Road Transport and Cargo Sector (STRC) and Ceilândia. Noise was measured by an instant reading meter carried by the evaluator, according to the methodology in the Occupational Hygiene Standard NHO-01 Assessment of Occupational Exposure to Noise. Eighty-five concrete deliveries were distributed among the drivers according to the company's logistics. All drivers under study had an Average Exposure Level below 82 dB(A), which is acceptable according to the NHO-01 standard, and three of those drivers did not present exposure levels above 80 dB(A) during the supervision. The normality of the results was verified by the Kolmogorv-Smirnov test. When using the t-test, no significant difference in exposure was found between the exposure means of the two regions under study nor between the morning and afternoon shifts. When considering the interference of load transportation related to noise exposure, due to the agitation of the load by the truck's mixer, the drivers presented statistically equal noise exposure, either during the delivery of concrete or their return to the batching plant. Also, according to the NHO-01 standard, even with levels considered acceptable, technical actions such as the maintenance of existing working conditions are recommended to ensure the well-being and health of the worker.*

Keywords: *Concrete Mixer Truck, occupational noise, concrete batching plants.*

1. INTRODUCTION

Noise is a physical agent that can harm health directly, when it results in temporary or permanent hearing loss; or indirectly, through biological disorders that can compromise the functional capacity of an individual (INST, 2000).

Noise-Induced Hearing Loss (NIHL) is considered the most common manifestation of occupational disease related to this exposure (INST, 2000). The NIHL results from continuous exposure to noise at high sound pressure levels, which generates irreversible and progressive damage to the hair cells in the Organ of Corti (FERREIRA JUNIOR, 1998; NUDELMAN et al., 1997).

According to (Nudelman et al., 1997), in addition to NIHL, people regularly exposed to high sound pressures may have adverse effects on physical and mental well-being, such as increased blood pressure, development of cardiovascular problems, cognitive problems, and neurological, behavioural and hormonal disorders.

Noise is considered an environmental pollution and it can be observed especially in industrial activities and areas of dense vehicle traffic. The authors (Alvarez and Pimentel-Souza, 2021) classify the traffic noise from motor vehicles as the main contributor to noise pollution in urban centers. Noise from vehicle engines and traffic congestion on major public access roads aligned to noise emission by the horns of impatient drivers are some of the factors responsible for noise pollution in major urban activities (BRASIL, 2000; ROSSI AND FERREIRA JUNIOR, 2004).

In a study developed by (Jamalizadeh et al., 2018) in the Qazvin region, Iran, which sought to characterize full noise exposure in taxi drivers, a higher incidence of noise exposure was observed in the evening in comparison to the results found for the morning period. According to the author, the increased circulation of cars in the evening may justify the observation above.

Similar to what was developed in the Iran region, an occupational noise exposure assessment was carried out in a comprehensive manner in Pakistan, by (Ahmad et al., 2018). The study evaluated the exposure in 100 civil transport drivers, divided into rickshaw drivers, taxi drivers, wagoner and bus drivers. The authors also highlight the intense exposure related to urban traffic, with 65% of the participants having presented hearing loss at some frequency range.

A concrete mixer truck driver represents one of the various professionals responsible for transporting people or materials. For (Clark et al., 2001) drivers are the key employees in the concrete industry and are responsible for the delivery of concrete at the construction sites and returning to the concrete batching plant.

The concrete mixer truck, illustrated by Figure 1, it is a vehicle used daily at concrete batching plants. The mixer of the truck, highlighted in Figure 1 it is intended to ensure mixing, homogeneity and to perform the transport of concrete.

In view of the harms related to occupational exposure to noise and the contribution to exposure due to urban traffic, this research sought to estimate and characterize the health risks to which mixer truck drivers may be affected during cargo transportation and return to the dosing plant.



Figure 1 – Representation of the concrete truck's mixer.

The drivers were evaluated by full monitoring and the study methodology was applied according to the procedure imposed by Brazilian regulations. In addition to the daily full exposure, parameters such as the volume of cargo transported, the region through which they travelled and their work shift were evaluated in order to better characterize occupational exposure.

2. MATERIAL AND METHODS

2.1 Methodology

The Brazilian regulation responsible for establishing procedures for noise exposure analysis is the Occupational Hygiene Standard (NHO) 01 – Assessment of Occupational Noise Exposure (Fundacentro, 2001). Within its scope, the standard brings up assessment methods, a definition of criteria and parameters, tolerance limits and indications of control measures for noise. The exposure limits presented by the regulation were based on the Regulatory Standard NR-15 – Unhealthy Activities and Operations (ISO – 1999, 2001), which are used for investigations and audits along with Instituto Nacional do Seguro Social (INSS).

Measurements were made by means of an instantaneous reading meter, with a weighting curve "A" and a "slow" response circuit, which covered a frequency range of 80 to 115 dB(A). The measurement interval (A_t) of 15 seg was used and exposure values below 80 dB(A) were not considered for the evaluation, as indicated by the regulations. Each n reading was divided into intervals of 0.5 dB(A), so that subjective means were not taken for any of the readings.

The different exposure values representing the daily working hours were used to obtain the Average Level (MN) for daily exposure, as presented in Eq. (1):

$$NM = 10 \log \left[\frac{1}{n} (n_1 x 10^{0,1NPS_1} + n_2 x 10^{0,1NPS_2} + \dots + n_i x 10^{0,1NPS_i} + \dots + n_n x 10^{0,1NPS_n}) \right], \quad (1)$$

in which NM is the average representative level of the worker's exposure, ni are the reading groups obtained every 0.5 dB(A), n is the total number of readings and NPS_i is the i -th average sound pressure level, that should be greater than 80 dB(A).

As presented by the normative, when the average level of exposure is representative of the entire daily working hours, it can then be considered as the Exposure Level (NE) itself. For comparative purposes of the noise exposure values found in the limits stipulated by the standard, the Normalized Exposure Level (NE) must be obtained (Fundacentro, 2001). By using Eq. (2), the normalization of the Exposure Level (NE) may be obtained for a standard eight-hour working day.

$$NEN = NE + 10 \log \frac{T_e}{480}, \quad (2)$$

in which NE represents the average level of exposure for the workday and T_e is the duration of the workday in minutes. The daily occupational exposure limit criterion for the NEN is 85 dB(A) and the exposure ceiling value for continuous noise corresponds to 115 dB(A).

The participation of drivers on the development of this research took place voluntarily and included eighteen drivers from Plant 1, located in the Road Transport and Cargo Sector (STRC) and ten drivers from Plant 2, located in the region of Ceilândia. In total, four of the thirty-two drivers contacted showed no interest in participating in the proposed study. The four drivers who refused to participate in the supervision informed that they understood the purpose of the study but would feel uncomfortable by being thoroughly supervised at work.

Thus, twenty-eight daily measurement sessions were carried out to acquire data on noise exposure for each driver participating in this research. Initially, the worker was submitted to an anamnesis questionnaire that aimed at a better characterization of the study sample. The questionnaire contained questions regarding occupational history, anthropometric data and social behaviours. The anthropometric characteristics of the drivers were acquired in loco, with the help of a digital scale and a tape measure, as illustrated by Figure 2.



Figure 2 – Obtaining anthropometric data: (a) mass. (b) height.

After the application of the questionnaire, the monitoring of the workday in an integral way began. The average level of exposure was obtained by means of an instant reading meter carried by the evaluator, as indicated in the current Brazilian regulations NHO-01 - Assessment of Occupational Exposure to Noise. Measurements occurred only inside the concrete mixer truck cab and individually for each driver during cargo transportation and return to the plant.

In addition to the daily exposure estimate, other characteristics were considered as possible contributors to noise exposure, such as: the regional difference between the two plants; the period in which the deliveries were performed, morning or afternoon; and whether there was interference from the load transported regarding exposure to occupational noise.

2.2 Characterization of the sample

Thus, of the thirty-two drivers contacted, twenty-eight (87.5%) agreed to participate in the development of the study, eighteen (64.3%) drivers from Plant 1 and ten (35.7%) from Plant 2. According to the anamnesis questionnaire applied, the average age of the participants was 39.1 (\pm 8.7) years old and their average Body Mass Index (BMI) was 27.3 (\pm 4.3) Kg/m². Regarding the habit of physical activities, such as walking, weight training or sports, 14 drivers (50%) had that regular habit. Alcohol consumption was reported at least once a week by 14 of the drivers interviewed (50%), and only 1 driver (3.6%) considered himself a smoker. When asked about discomfort regarding the exposure to noise emitted by the truck and/or urban traffic, 22 drivers (78.6%) reported having no perception of the exposure.

2.3 Data Collection

Data related to occupational exposure to noise were collected according to the methodology imposed by the Regulatory Standard NR-15 Unhealthy activities and operations, as well as its technical considerations and recommended actions. An instantaneous reading meter, Class 1, model SC101, from the manufacturer CESVA® was used for data acquisition. As instructed by the regulations, the microphone must be at a maximum distance of 15 cm from the ear canal. The meter was attached to the truck's seat, as illustrated by Figure 3.



Figure 3 – Adaptation of sound pressure meter: (a) model used. (b) adaptation of the model to the seat (c) microphone next to the driver ear. (d) driver during working hours.

The configuration of the SC101 apparatus was performed based on instantaneous exposure in integration. The device was used in a slow response and the exposure values were recorded manually in a time interval (Δt) of 15 seconds.

3. RESULTS AND DISCUSSION

During this research, eighty-five concrete delivery cycles distributed among the 28 drivers were carried out. Each cycle corresponded to the concrete delivery path and the return of the truck to the plant, which were measured independently. The noise emitted by the plant while drivers were waiting for the load to be transported was not considered for this study due to the availability of the use of Personal Protective Equipment (PPE) during that phase of the process.

In delivery routes, data acquisition began as the trucks left the concrete batching plant and their arrival at civil constructions established the ending point. As for the return routes, the acquisition of data began with the exit of the civil constructions and ended with at the entrance of the concrete batching plant.

The average daily exposure levels acquired for each driver can be seen in Figure 4. Three of the twenty-eight drivers under study did not present significant exposures to occupational noise according to the methodology used, which disregards exposures below 80 dB(A). Those three drivers had air-conditioned vehicles, which allowed them to keep the windows fully closed throughout the delivery and return routes to the batching plant.

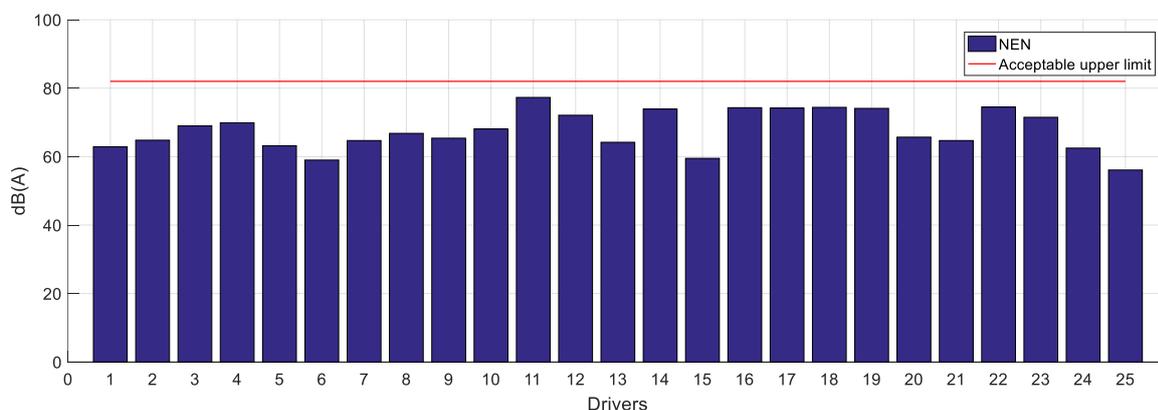


Figure 4: Average levels of daily exposure obtained.

Thus, none of the twenty-five drivers presented in Figure 4 showed exposure to occupational noise above the “Acceptable Range” of 82 dB(A) imposed by (Fundacentro, 2001). The twenty-five samples presented an average exposure value of 73.5 (± 5.6) dB(A), with the highest exposure value obtained by the driver twenty-one, at 81.6 dB(A); and the lowest exposure value obtained by the eleventh driver, at 61.2 dB(A). The normality of the results was ensured by the Kolmogorov-Smirnov test.

Although none of the drivers presented occupational exposure to noise above the tolerance limits, parameters such as the variation of the load transported, the difference in location of the batching plants and the drivers' work shift were evaluated as possible contributors to occupational exposure.

Each journey of the trucks was evaluated individually in order to identify the influence of the load volume transported, related to the possible effort of the engine to maintain the constant agitation in the mixer. However, only exposure values above 80 dB(A) were considered for the analysis, as proposed by the regulations used, which resulted in fifty-three concrete delivery cycles illustrated by Figure 5.

For the fifty-three cycles identified, twenty-eight cycles (52.8%) demonstrated higher noise exposure during the return to the batching plant. The greater occupational exposure to noise during the return might be related to the increase in traffic speed adopted by the vehicles. For safety reasons, there is a speed limit which drivers can reach for load transport conditions.

In this study, it was not possible to verify the occupational noise exposure conditions for the same traffic speed conditions. In addition to the unforeseen events derived from urban traffic itself, drivers receive salary increases according to the production of the batching plant. As a result, they sought to return to the center as soon as possible to make new deliveries.

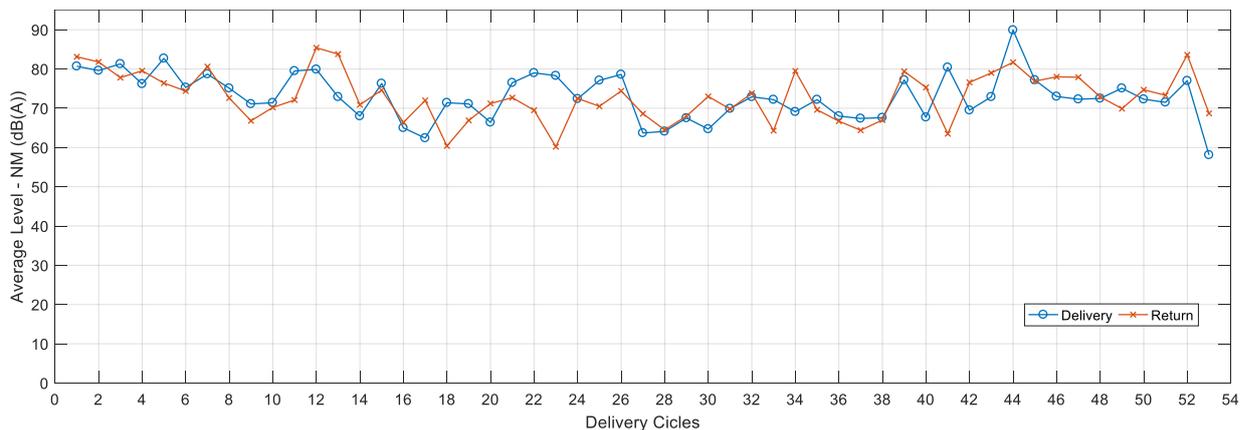


Figure 5: Contributions of concrete delivery and return journeys.

The assessment of the period in which the deliveries were made was based on the study previously presented by (Jamalizadeh et al., 2018), in which the author identified the period in which drivers present the highest risk of occupational exposure to noise.

For the present study, the morning shift was classified as dislocations, whether they were concrete deliveries or returns to the plant, which occurred in the period between 07 am and 12 pm. For the afternoon period, dislocations that occurred between 12 pm and 07:30 pm were considered. For comparison purposes, Figure 6 presents only the drivers whose exposure in both periods, morning and afternoon, exceeded 80 dB(A).

In general, 03 of the 25 trucks did not present exposure to noise higher than 80 dB(A) in the morning. In the afternoon, all 25 trucks contributed to noise exposure.

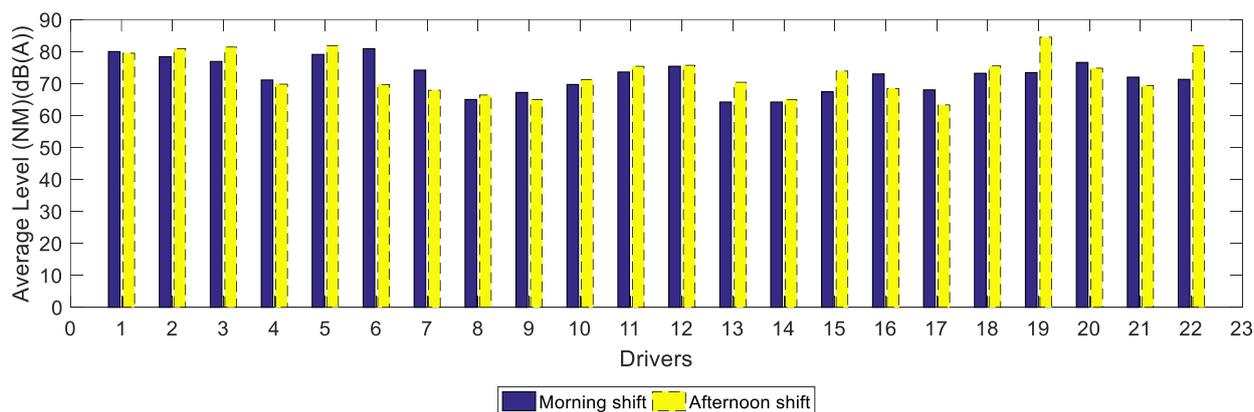


Figure 6: Comparison of exposure between morning and afternoon shifts.

For fifteen (60%) of the evaluated drivers, the period of greatest exposure was the afternoon, which may be associated with the increase in vehicle traffic on urban roads in that period of the day, as evidenced by other authors (JAMALIZADEH ET AL., 2018).

The average noise exposure for the morning shift was 72.5 (± 5.1) dB(A), and 73.2 (± 6.3) dB(A) for the afternoon one. When performing the paired t-test between the two work shifts, it was possible to verify that, on average, the morning exposure value ($M=72.5$) was equal to the average afternoon exposure value ($M=73.2$), $t(21) = 0.523$, $P > 0.05$. Therefore, no significant difference was found between the exposure periods analysed.

Finally, the regional difference between the dosing centres was evaluated in order to verify the influence of local urban traffic in relation to occupational exposure to noise. The batching plant (1) is located in a region of load transportation, with access to streets and avenues. The batching plant (2) is located in a region with quick access to highways, with intense vehicle traffic. Figure 7 shows the comparison between the exposure levels obtained for the two plants.

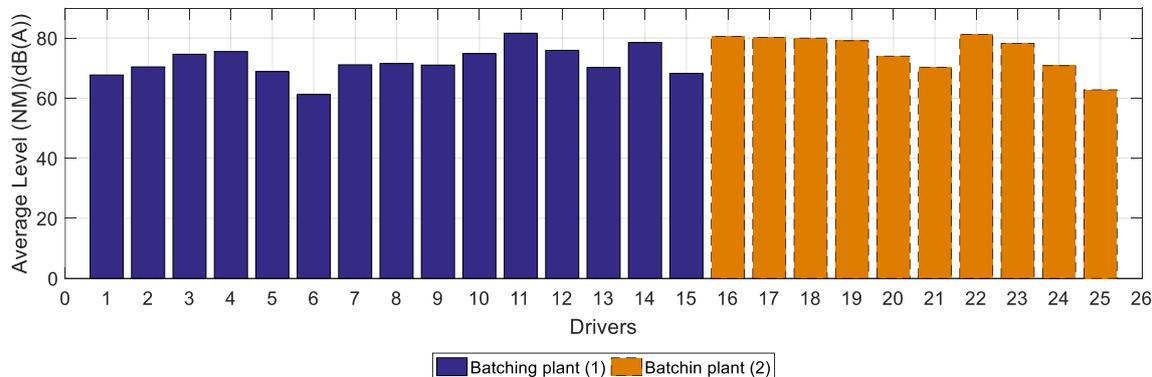


Figure 7: Comparison of exposure between plants.

The data presented in Figure 7 corresponds to the twenty-five drivers considered for noise exposure, fifteen from Plant (1) and ten from Plant (2). The average found for the noise exposure values in Plant (1) was 72.0 (± 4.6) dB(A), while it was 75.7 dB (A) (± 6.0) for Plant (2).

For Plant (1), the highest exposure value obtained was 81.6 dB(A), presented by the eleventh driver, while the sixth driver presented the lowest exposure value, 61.2 dB(A). For Plant (2), the extreme exposure values were obtained for the twenty-second and twenty-fifth drivers, with the highest exposure value at 81.2 dB(A) and lowest at 62.8 dB(A), respectively.

Despite the difference in location and different characteristics of urban traffic, when applying the t-independent test between the two different plants, no significant difference was found between the averages of exposures obtained ($t(23) = -1.95$; $p > 0.05$).

4. CONCLUSIONS

In the present study, occupational exposure to noise on mixer truck drivers was characterized, seeking to prevent the possible occupational risks that arise from their profession. Exposure values above the limit established by current

regulations were not recorded. However, when comparing trucks that had air conditioners with those that did not, the reduction of noise exposure levels was verified, since drivers had the option of traveling on highways and urban roads with windows fully closed.

When verifying the regional difference in the contribution of exposure to occupational noise, no significant difference was found between the averages of exposure obtained between the two plants ($p>0.05$). The same occurred when verifying the difference in exposure to occupational noise between the morning and afternoon work shifts. No significant difference was found between the exposure averages obtained for the two plants ($p>0.05$).

When comparing the noise exposure values due to load transportation, the noise exposure value obtained for concrete delivery was evaluated as statistically equal to the noise exposure value obtained for the return of the truck to the plant.

5. ACKNOWLEDGEMENTS

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