Short review on occupational noise exposure in the extractive industry and similar works

J. Duarte[1], J. Castelo Branco[2], Fernanda Rodrigues[3], J. Santos Baptista[4]

[1]Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jasduarte@fe.up.pt) ORCID 0000-0002-5856-5317, [2]Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jcb@fe.up.pt) ORCID 0000-0002-9254-4384, [3]RISCO, ANQIP, University of Aveiro, PT (mfrodrigues@ua.pt) ORCID 0000-0001-9127-7766, [4]Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jsbap@fe.up.pt) ORCID 0000-0002-8524-5503.
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Abstract

Introduction: Occupational noise is still a matter within the industrial practice with nefarious consequences on the worker's health. Pulmonary diseases, cardiovascular problems, disturbances in sleep, fatigue, and, in the worst-case scenarios, hearing loss (this one with a permanent character) are some of the most common adverse effects reported in the literature. This issue covers itself in even more significant concern when analysing the mining industry context. Almost every operation works as a potential noise source, not only for the workers but also for the surrounding populations. Objective: To identify the exposure setting to occupational noise in the extractive industry and similar works (i.e. earthworks), particularly related to tasks and equipment. Methodology: The Preferred reporting items for systematic reviews and meta-analyses (PRISMA) was used as a guideline to help conduct the research and report of this work. The most relevant keywords were selected and later combined in the selected databases and multidisciplinary academic journals in the first phase. After, the articles were filtered with a set of exclusion criteria, to know: 1) Publication year, 2) Document type, 3) Source type, and 4) Language. The subsequent stage was to determine, within the remaining articles, the pertinence of each study and its later inclusion in the study. Each set of data was then classified according to the measurement context, and the results were analysed. Results and discussion: In the records' identification phase, a total of 1148 papers were recovered. By applying the previously mentioned exclusion criteria, 547 were removed related to publication year, 146 due to document type, 12 related to source type and 25 because of language. Additionally, 360 records were excluded because were not in accordance with the proposed objective, 25 were duplicate articles, and 7 had no full-text available. From the last analysis, 11 more papers were excluded, which lead to a final result of 15 included studies. According to the occupational noise measurements set, the records were divided into four categories: activity, equipment, job category, and working area. Different equipment was associated with high noise levels: crusher – between 85.6 and 104 dB, trucks and bulldozes – above 100 dB, and shovel – 103 dB, whereas the only analysed activity was blasting, where studies concluded that increasing distance leads to lower noise measurement values. Conclusions: Considering this research, although it was possible to identify the tasks and equipment usually associated with occupational noise in the extractive industry, a lot of work still needs to be done, especially data analysis. However, this research serves as a starting point for future study.

Keywords: Open pit mine, Earthworks, Equipment, Occupational noise.

INTRODUCTION

Worldwide, occupational noise-induced hearing loss (ONIHL) is still a significant health issue (Zhou, Shi, Zhou, Hu, & Zhang, 2020), mainly because noise is not dissociable from industrial practice, where the consequences are felt in terms of disease burden and financial aspects, both for the worker and society (Chen, Su, & Chen, 2020).

The phenomenon of noise is complex and depends not only on its physical characteristics (such as frequency and sound pressure level) but also on the individual's physiological features. For instance, it is known that the earing canal exponentiates the sound pressure level perceived by the ear and that this occurs more in men than in women (Asady, Fuente, Pourabdian, Forouharmajd, & Shokrolahi, 2021).

General hazardous effects of noise on health include, though are not limited to, sleep disturbance (Ntlhakana, Nelson, & Khoza-Shangase, 2020), pulmonary diseases, type 2 diabetes, fatigue, distraction (Hon, Tchernikov, Fairclough, & Behar, 2020), cardiovascular problems

(Asady et al., 2021; Hon et al., 2020) and hypertension (Li et al., 2019). The noise exposure was also associated in the literature with injury and accident occurrence, as the annoyance effect clouds judgment and endangers action (Hon et al., 2020; Li et al., 2019).

In the extractive industry context, every task and equipment is fairly associated with noise: drilling and blasting, rock and ore transportation, the movement of the machines themselves such as trucks, excavators, bulldozers and many others (Lilic, Cvjetic, Knezevic, Milisavljevic, & Pantelic, 2018; Wichers, Iramina, de Eston, & Ayres da Silva, 2018). Similarly, earthworks, as an example of similar works, uses the same processes and machines, therefore poses the same risks. However, excessive occupational noise is preventable (Hon et al., 2020). Understanding the general processes that contribute to this problem and mitigate its effects, achieved by carefully planning even the simplest operations.

This short review aimed to identify, in the literature, tasks and equipment related to occupational noise in the extractive industry and similar works (involving the same type of equipment and processes).

METHODOLOGY

This short review follows the Preferred reporting items for systematic reviews and meta-analyses (PRISMA) methodology (Moher et al., 2009; Page et al., 2021) and the guidelines proposed by Duarte et al. (2020) in the context of occupational noise exposure in the mining industry and earthworks. The first step was to select the main databases and journals and then, to apply the most appropriate keyword combinations. “Noise” was sequentially combined with “quarry”, “open pit”, “open cast”, “surface mining”, “open cut mining”, “extractive industry”, and “earthworks” in the Title/Abstract/Keywords field on Dimensions, Directory of Open Access Journals, Science Direct, Emerald, IEEE Xplore, INSPEC, SAGE journals, Scopus, Taylor and Francis, Current Contents and Web of Science. As exclusion criteria, the following filters were applied: 1) Publication year (≥ 2010), 2) Document type (everything other than research articles and articles in press were excluded), 3) Source type (only journals and trade publications were considered), and 4) Language (only English-written papers were considered).

Afterwards, every title and abstract were assessed to determine the eligibility of the selected works and only papers in occupational context and providing field data were considered and included in this preliminary study. The preliminary analysis focused on the origin country, activity, type of exploitation, and exploited commodity. Then, data was classified according to the measurement setting to organise information and create comparable standards. From that classification, a narrative appraisal was carried out. This research was carried out in February 2021.

RESULTS AND DISCUSSION

The primary research provided 1148 results. By applying the prior filters, 547 papers were removed due to 1) Publication year, 146 were excluded in relation to 2) Document type, 12 were removed regarding 3) Source type, 25 records were excluded due to 4) Language. After reading the title and abstract of each work, 360 more papers were excluded because they were not within the proposed objective. From the remaining 58 records, 25 were duplicates; therefore, they were also excluded from the research. Additional 7 records had to be removed after not reaching the main author for a full-text retrieve. This led to a total of 26 to full appraisal and discussion, after which more 11 papers were removed attributable to one (or more) of the following reasons: the article only had theoretical data, the field data did not occur in occupational context, the article did not provide actual field data despite occupational protocol. At the end of this analysis, 15 papers were included in this short review.

Except for one study that takes place in the construction field (Lee, Kim, & Hong, 2019), every other paper set is related to the mining industry, where the exploited commodities varied between marble (Melo Neto, Kohlman Rabbani, Barkokébas Junior, Lago, & Jonathas, 2012) to aggregates (Onder, Onder, & Mutlu, 2012) and andesite (Kosała & Stępień, 2016), limestone (Çınar & Şensöğüt, 2019), coal (Simion, Kovacs, Toth, Ilie, & Gireadă, 2017) and lignite (Srivastava, Gupta, Srivastava, & Kaur, 2010), chromite (Kerketta, Gartia, & Bagh, 2012), copper (Lilic et al., 2018) and iron (Lokhande et al., 2017).

Given that this study's aim is related to occupational exposure to noise, the experimental data was classified according to the measurement setting, which is provided in Table 1, divided into activity, equipment, job category, and working area.

Table 1. Occupational noise measurement setting

Author, year	Activity	Equipment	Job category	Working area
(Srivastava et al., 2010)	x			
(Gupta, Roy, & A. Rajan B, 2012)		x		
(Kerketta et al., 2012)				x
(Melo Neto et al., 2012)			x	
(Onder et al., 2012)			x	
(Cinar & Sensogut, 2013)		x		
(Gyamfi, Amankwaa, Owusu Sekyere, & Boateng, 2016)		x		
(Kosała & Stępień, 2016)	x	x		
(Lokhande et al., 2017)				x
(Simion et al., 2017)		x		
(Lilic et al., 2018)		x		
(Wichers et al., 2018)		x		
(Çınar & Şensöğüt, 2019)				
(Lee et al., 2019)		x		
(Mihut, 2019)		x		

Regarding activity, both studies (Kosała & Stępień, 2016; Srivastava et al., 2010) focused on the blasting operation, where increasing distance leads to lower noise measurement values. The peak pressure level measured at 200 metres from the blast was 132 dB (Srivastava et al., 2010), whereas the equivalent continuous sound pressure level (Leq) for an 8-hour period was 53.3 dB at 86 metres, 37.2 dB at 155 metres, and 31.0 dB at 186 metres.

The selected equipment for each study is detailed in Table 2.

Table 2. Studied equipment

Author, year	Equipment
(Gupta et al., 2012)	Jack hammer drill
(Cinar & Sensogut, 2013)	Bulldozer, cone crusher, excavator, grader, hydraulic hammer, jaw crusher, mill, sieve, truck
(Gyamfi et al., 2016)	Drilling machine, tyre wrench, lathe machine, block making machine, generator set, crusher machine, primary processing machine, secondary processing machine, excavator machine, air compressor
(Kosała & Stępień, 2016)	Crusher, siever, vibrating feeder, wheel conveyor, conveyor, dispenser aggregate for the loading silo
(Simion et al., 2017)	Bucket-wheel excavator
(Lilic et al., 2018)	Truck, shovel, bulldozer, drilling rig, grader, crusher, belt conveyor
(Wichers et al., 2018)	Asphalt mixer, drilling rig, crushing plant
(Lee et al., 2019)	Air compressor, breaker, bulldozer, compactor, crusher, drill, excavator, grader, jack hammer, loader, roller
(Mihut, 2019)	Truck, tractor, motor hacksaw, charger, bulldozer, excavator

Overall results showed that heavy machinery such as trucks and bulldozers had noise levels above 100 dB(A) (Lilic et al., 2018), crusher (despite type – cone or jaw) produced noise levels between 85.6 and 104 dB(A) (Cinar & Sensogut, 2013; Gyamfi et al., 2016; Lee et al., 2019; Lilic et al., 2018), and shovel 103 dB(A) (Lee et al., 2019). Two studies applied the experimental protocol before and after equipment maintenance (Cinar & Sensogut, 2013; Simion et al., 2017) and concluded that the noise level lower after an intervention.

Only two studies recorded noise related to job category (Melo Neto et al., 2012; Onder et al., 2012). Melo Neto et al. (2012) experimental protocol was applied at two marble finishing plants, where polisher workers were exposed to equivalent continuous sound pressure levels between 99 and 105 dB(A) and cutting workers were exposed to noise levels between 100 and 101 dB(A). Office workers were exposed to values below 87 dB(A). In the other study, the job categories of cook, crusher worker, drilling operator, driver, mining machine operator, weighter and work site chief were analysed. The highest exposure was measured for one of the mining machine operators (108 dB(A)) and the drilling operator (95 dB(A)). However, all crusher workers were exposed to noise levels above 90 dB(A).

Finally, regarding the working area, there were two studies (Kerketta et al., 2012; Lokhande et al., 2017). Industrial area measurements varied between 53.31 and 72.29 dB(A), commercial area ranged between 58.33 and 78.65 dB(A), and work zone, which included heavy machinery, blasting zone and processing plant, varied between 54.79 and 100.56 dB(A) (Kerketta et al., 2012). In the other study, industrial area occupational noise ranged between 64.2 and 73.4 dB(A) during the day, and between 55.2 and 64.4 dB(A) during the night. In the commercial area, the ranges were 62.2-72.7 dB(A) (day) and 52.6-55.6 dB(A) (night); at the mine sites, these values were higher, ranging between 91.1 and 117 dB(A) during the day, and 61.3 and 120.5 dB(A) at night time. Moreover, three haulage roads were assessed, and the measurements were between 61.3 and 71.1 dB(A) (Lokhande et al., 2017).

Despite this general narrative analysis, it is important to state that cultural context should be considered while assessing the results, as specific norms and standards may apply. For instance, in Europe, there are regulative norms that apply to every country. The same does not happen in other parts of the world, were these standards may vary. More focused analysis has to be carried out concerning the comparable data.

CONCLUSIONS

This short review aimed to identify the tasks and equipment associated with noise exposure in the extractive industry and similar works. However, while trying to classify the data and due to the nature of papers, two additional categories were added: job category and working area. Fourteen out of the fifteen papers were in the mining industry and one in the construction industry despite describing similar works. Specifically related to tasks, only the blasting operation was addressed (Kosała & Stępień, 2016; Srivastava et al., 2010), although the list of operations that stand as noise sources (Wichers et al., 2018). On the other hand, regarding equipment, a plethora of examples were provided: bulldozer, jaw and cone crusher, different kinds of sieves, conveyor, excavator, truck, shovel, among many others. Interestingly, most of this equipment presented high noise levels (of 80 dB and above). Only comparable data was used in this work as some of the articles presented their results in graphic form. The job category was created to answer two studies that analysed personal noise level exposure of polisher worker and cutter worker (Melo Neto et al., 2012), and crusher worker, drilling operator, driver, mining machine operator and weighter (Onder et al., 2012). Commercial and industrial zone, mines, and haulage road were mentioned as the understudy working areas (Kerketta et al., 2012; Lokhande et al., 2017).

From this primary research, it was not possible to identify exposure settings other than the classifications made. However, this primary investigation has set the tone for the subsequent research that has to be carried out: additional records have already been identified and have to be compared to the eligibility standard so to deepen the analysis. Statistical data treatment will needs to be performed to the final set of information. The ultimate objective will be to design the processes and activities having in consideration the nefarious consequences of such exposure not only to workers but also to the surrounding communities.

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