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Noise Risk Assessment in a Modern Olive Oil Mill

Mariangela Vallone*, Giuseppe Morello, Pietro Catania

University of Palermo, Dipartimento Scienze Agrarie, Alimentari e Forestali, Viale delle Scienze ed. 4 - 90128 Palermo, Italy
mariangela.vallone@unipa.it

High levels of noise usually occur in olive oil mills because of the machines used to extract olive oil with a continuous plant. In Italy Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a number of procedures to be adopted at different noise levels to limit workers exposure. This study aims at evaluating the equivalent and peak noise levels inside a modern oil mill plant area in Sicily, south Italy. Twenty measurement points were identified inside the oil mill plant area where the machines for olive oil extraction were located (about 200 m^2). The instrument used for the measurements was a precision integrating portable sound level meter, class 1, model HD2110L by Delta OHM, Italy. The measured sound levels exceeded the limits allowed by the regulations in all the measurement points inside the working area; values exceeding the threshold limit of 80 dB(A) were recorded coming up to a maximum value of 93.3 dB(A) close to the hammer crusher. The operators involved are consequently obliged to wear the appropriate Personal Protective Equipment.

1. Introduction

Noise is a relevant risk factor to be taken into account in evaluating health and safety of workers in agriculture (Vallone & Catania, 2013).
High levels of noise usually occur in oil mill plant because of the machines used to extract olive oil especially inside oil mills that use continuous cycle systems. Directive 2003/10/EC of the European Parliament was enacted on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise). It stipulates an upper average limit of noise exposure of a worker during an eight hours shift of work at 85 dB(A). This level is supposed to inhibit hearing impairments of workers (Moselhi et al., 1979). Even the ILO (International Labour Organization) indication agrees with this.
In Italy, Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a series of procedures to be adopted at different noise levels to limit workers exposure. Excessive noise, in fact, is a global occupational health hazard with considerable social and physiological impacts, including noise-induced hearing loss (NIHL) (Deborah et al., 2005). Operators may also develop ringing, whistling, buzzing or humming in the ears, a distressing condition which can lead to disturbed sleep. Noise at work can interfere with communications and make warnings harder to hear; these factors can lead to safety and health risks.
To the best of our knowledge, few studies have been published on noise risk assessment in olive oil mills. Porceddu and Dionigi (2010) evaluated the noise level inside some olive oil mills in central Italy, both continuous and traditional mills, obtaining higher noise levels in continuous olive mills than in traditional ones depending on the different machines used (crusher with hammers, millstone). In the continuous olive mills crushers and decanters (horizontal centrifuge) were the most dangerous machines. Proto et al. (2011) measured the noise levels in a representative Calabrian oil mill in terms of covered area (150 m^2) and work capacity (3500 kg/h). The Jordan situation was described in Hammad et al. (2015) measuring noise levels in several olive mills of the continuous type in Jordan.
This study aims at evaluating the equivalent and peak noise level inside a modern olive oil mill plant area in Sicily, south Italy, the third Italian region both for olive grove surface and for olives production.

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2. Materials and methods

2.1 Olive oil mill plant

The oil mill plant examined in this study was a continuous cycle plant equipped with the following machines (Catania et al., 2015): discharge tank, defoliator, washing machine, hammer crusher, six malaxation machines, horizontal decanter, and vertical centrifuge (Figure 1). Two operators controlled the different phases of the process.

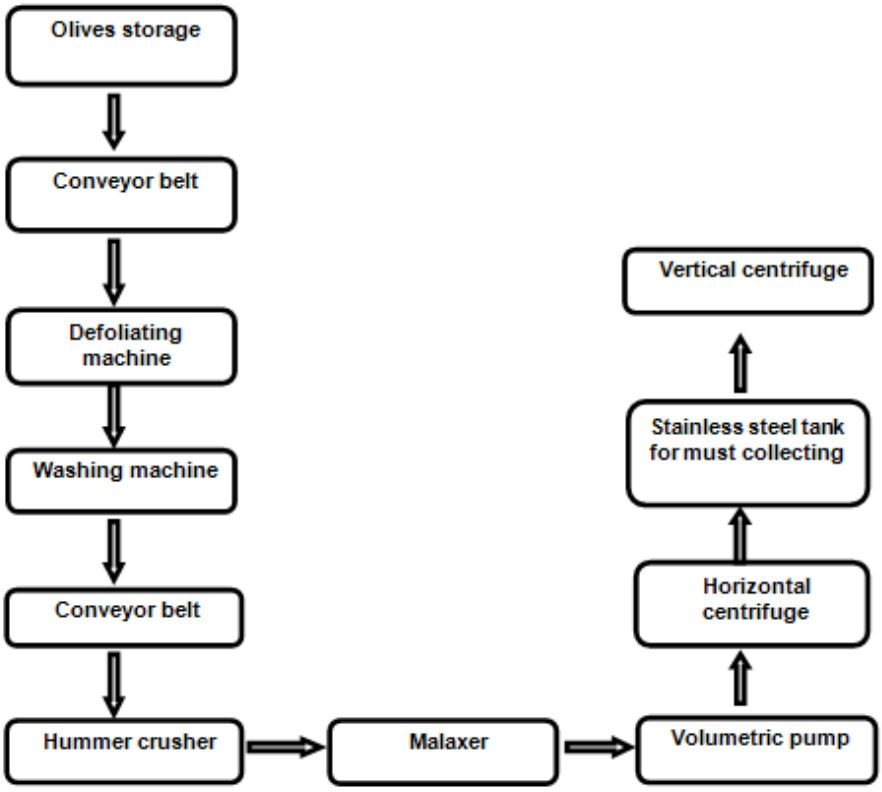

Figure 1: Block diagram of the olive oil extraction process.

2.2 Experimental tests

The instrument used in the tests is a precision integrating portable sound level meter by Delta OHM, Italy, model HD2110L (Figure 2).

Figure 2: HD2110L integrating portable sound level meter by Delta OHM, Italy used in the tests. Figures and figure captions should be placed flush-left; two narrow figures may be placed side-by-side.

The oil mill area had an almost rectangular plant with an area of approximately 200 m^2. Twenty measurement points were located through a square mesh whose sides were orthogonal with respect to the sides of the room (Figure 3).

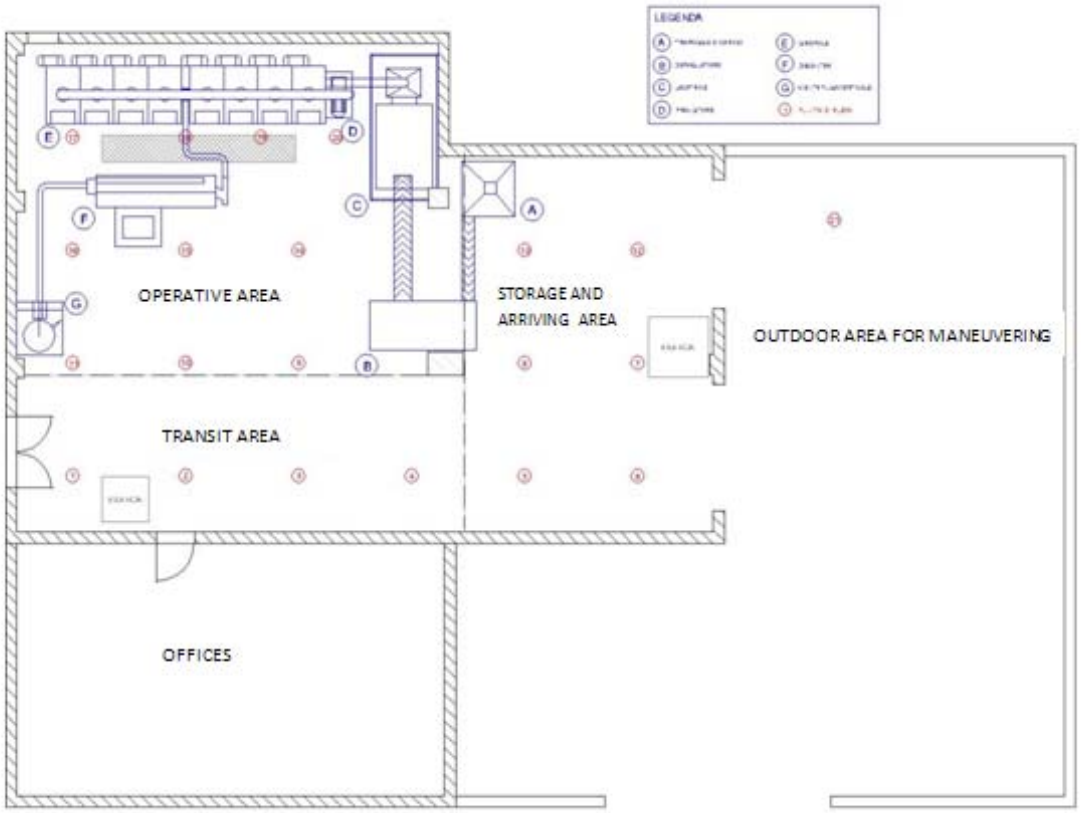

Figure 3. Plan lay out of the oil mill area and measurements points.

The sound level meter was positioned at a height of 1.60 m from the ground with the aid of a tripod; each measurement had a duration of 2 minutes (the case of stationary noise source) and the parameters were analyzed at intervals of 0.5 seconds. The measurements were carried out during the olive oil mill full activity in November, 2015; the machines were all simultaneously working.

The tests were performed in compliance with EN ISO 9612 and UNI 9432 regulations. We measured A-weighted time-averaged sound pressure level (L_{Aeq}) and C-weighted peak sound pressure level (L_{Cpk}).

According to article 3 of Directive 2003/10/EC of the European Parliament and article 189 of Italian Law Decree 81/2008, the exposure limit values and exposure action values in respect of the daily noise exposure levels and peak sound pressure are fixed at:

Lower exposure action values: $L_{EX,8h}$ = 80 dB(A); p_{peak} = 135 dB(C);

Upper exposure action values: $L_{EX,8h}$ = 85 dB(A); p_{peak} = 137 dB(C);

Exposure limit values: $L_{EX,8h}$ = 87 dB(A); p_{peak} = 140 dB(C).

where $L_{Eex,8h}$ values (occupational noise) is reported to 8 working hours.

$L_{Eex,8h}$ value is given by the following equation:

$$L_{EX,8h} = L_{Aeq,Te} + 10 \log (T_e / T_0)$$

where Te is the effective duration, in hours, of the working day and T_0 is the reference duration equal to 8 hours. In this case T_e was assumed to be 7.5 hours.

The exposure limit values represent the noise level that can not be exceeded in every working condition; the lower and higher action values require the employer to take specific protection measures for the operators. If the lower value is exceeded, activities of “information, formation and PPE supply” must be carried out; if the higher value is exceeded, actions of “information, training and PPE supply with the obligation of use” are needed, as pointed out by Proto et al. (2011).

Before each series of measurements, the instrument calibration was performed applying a sound calibrator. The collected data were downloaded to the PC for further processing.

The map of equal loudness curves was realized using the commercial software Surfer 12 (GOLDEN SOFTWARE, LLC, USA) and applying linear interpolation. The map was obtained from a grid file where X and Y were the coordinates of the measurement points and the third dimension (Z), that was the measured value of L_{Aeq} , was represented by lines of equal value. The area between two contour lines contains only grid nodes having Z values within the limits defined by the two enclosing contours.

3. Results and discussion

The data obtained by the measurements allowed to have the equal loudness curves, thereby evaluating the zones with equivalent average sound levels (Figure 4).

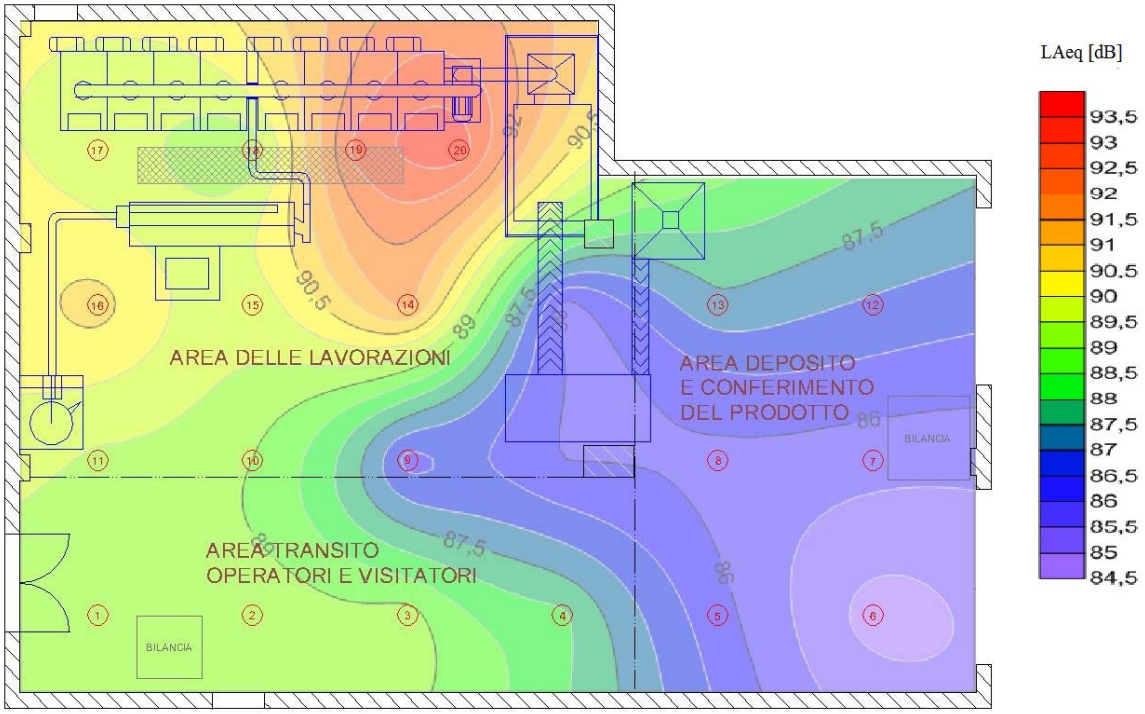

Figure 4. Map of equal loudness curves.

The A-weighted time-averaged sound pressure levels were always higher than the lower exposure action value of 80 dB(A). The minimum noise level was in correspondence of the measurement point number 6 which is located near the storage area, equal to 84.8 dB(A). The highest value of 93.3 dB(A) was recorded near point number 20, close to the hammer crusher. Also Proto et al. (2011) obtained acoustic levels equal or higher than 85 dB(A) in all the measurements points of an oil mill with a continuous-cycle plant similar to the oil mill considered in this study. In particular, they registered high levels near the washing machine (90.2 dB(A)) and the hummer crusher (86.7 dB(A)). Even Hammad et al. (2015) obtained noise levels in the range 85-95 dB(A), showing a very critical situation in Jordan considering that some operators work for more than 8 hours per day.

In our tests, the highest noise risk for the workers is close to the hammer crusher and the malaxation machines, where the highest noise level was recorded in agreement with the results obtained by Panaro et al. (2005) and Porceddu and Dionigi (2010).

As a consequence, the use of appropriate PPE (Personal Protective Equipment) is required when limits imposed by the regulations are exceeded. In this case, the employer provides workers with personal protective equipment, demanding the use if noise levels exceed 85 dB(A).

With reference to the peak values, neither the exposure limit value equal to 140 dB(C), or the upper and lower action values (equal to 137 dB (C) and 135 dB (C)) are reached or exceeded in any of the measurement points.

In the measurement points number 14, 16, 19 and 20 LAeq exceeded 90 dB(A); according to the law we are in the presence of dangerous areas where only specialized personnel may access. In all the other measurement

points, LAeq was in the range 85-90 dB(A); therefore it is obliged to use personal protective equipment and carry out an annual audiometric test.

4. Conclusions

The results show that noise pressure values measured during the test are always higher than the lower action value identified by law, equal to 80 dB(A) In particular, the upper action value equal to 85 dB(A) is reached in all the measurement points located inside the operation area. As a consequence, the use of appropriate PPE is required when limits imposed by the regulations are exceeded.
With reference to the peak values, neither the exposure limit value equal to 140 dB(C), or the upper and lower action values (equal to 137 dB (C) and 135 dB (C)) are reached or exceeded in any of the measurement points.
The authors who published data on noise levels in olive oil mills unanimously conclude that it would be important to adopt specific balancing measures or precautionary interventions, and limit the access only to the employers with appropriate personal protective equipment. In some non-EU states a further effort is required to improve legislation in order to implement safety measures.
Furthermore, some precautions can be suggested on structures, as the use of suspended soundproof ceiling panels (sound baffles) or the choice of irregular plan layout for example in C or L forms as they enable positive acoustic shielding effects.
The plan layout of the machines is very important because the sound pressure waves reflection on the walls can trigger resonance phenomena with the consequent exaltation of the sound effects, especially if they are in proximity of the machines for olive oil extraction. In the design phase, it is appropriate to place the machines at least 2 – 3 m from the walls, in particular the hammer crusher, the malaxer and the horizontal centrifuge and also to avoid rigid coating surfaces close to these machines. In the case of interventions on existing structures, sound-absorbing panels can be installed on the walls.

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