Noise operator exposure in olive oil mills

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Abstract

Noise in work environment is among the major causes of concern for safety and health of the industrial workers, as it causes annoyance and hearing loss. As with most occupational diseases, recognition and assessment of noise exposure are the foundations on which preventive measures and treatments are based. Aim of this study was to identify the predominant noise sources in the workrooms of two small olive oil mills in the South-East of Sicily and to measure the extent of noise exposure of the workers. The two mills differ essentially for the crushing system: based upon a millstone in the former and upon a steel-hammer type in the latter.
The results showed quite high sound pressure levels, especially in the second mill (average of 93.7 dB(A)). In the first mill, sound pressure levels ranged from 75.2 up to 94.4 dB(A), depending from the machines running contemporarily. The main sources of noise were the leaves remover and the washing machine in both mills, as well as the steel hammer-type crusher in the second mill.

Key words: occupational disease, safety, health.

Introduction

The olive growing has a fundamental role in the Italian agro-industrial economy, especially in the Southern Italy, where it is concentrated the greatest national production of olive oil. Moreover, this sector generates a job application of about 30 million of working days and classifies Italy at the second best world olive oil both as producer and exporter, after Spain. In particular, Italy is the first olive oil supplier for the USA (CO.RE.R.A.S., 2007).

In this national contest, Sicily is one of the leading regions both for invested surface (158 502 ha) and for olive production (313 705 t). However, despite the presence of 8 protected origin denominations (DOP) for the Sicilian olive oil production, less than 1% of product is certified. This is due to the high incidence of small olive farms: in fact, only 6.2% of these have an extension greater than 10 ha. Moreover, most of the olive oil production is destined to self-consumption or direct marketing, without any packaging (CO.RE.R.A.S., 2007).

Due to this organization, a great number of small oil mills (about 687 during the olive year 2004–2005) are active. Frequently, they have a family management and the working day duration is much longer than 8 hours, because of the limited period per year during which the plants are functioning.

Noise in oil mills is among the main sources of risk for safety and health of the workers, as it causes annoyance and hearing loss (Landström *et al*., 1995; Middendorf, 2004; Prasanna

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Kumar *et al*., 2008). On the other hand, the Italian regulation in force (Government Decree 9th April 2008, no. 81) states that the risk evaluation report must be carried out also for the family management activities. Therefore, it is necessary to carry out the recognition and the assessment of noise exposure on which preventive measures and safety interventions can be based.

This research intends to evaluate the noise level in two small oil mills with different crushing systems and similar oil separation systems. The paper reports the noise levels measured in each oil mill near each working position so to identify the machines mainly involved in causing high sound pressure levels.

Materials and Methods

The oil mills

Measurements of the sound pressure levels were carried out in two small olive oil mills: the first located in Regalbuto, in province of Enna, and the second in Noto, in province of Syracuse. The two oil mills have different period of installation, the same extraction system, but different crushing system. In fact, the former adopts a traditional millstone crusher, while the latter uses a steel hammer-type crusher. Therefore, the first one has mostly a batch functioning and the second a continuous one. In practice, also the second oil mill has a batch functioning, because during the same working day several small olive consignments of different farmers are milled and the oil must be separated for each of them.

The plant layout is different too due to the greater space taken by the millstone crusher system and to the shape of the workroom: almost square for the older oil mill (Figure 1) and rectangular for the most recent one (Figure 2).

Figure 1. The oil mill in Regalbuto (province of Enna).

In detail, the two oil mills have the same feeding system consisting in a hopper followed by an elevator belt and a leaves remover based on a very fast airstream produced by a radial fan. After there is the washing machine; only in the first oil mill it is preceded by a second hopper that permits to stock the olives before the crashing, so allowing its activation in different times with respect to the leaves remover and improving the batch functioning. Then the olives reach the crushing system by means of an inclined screw elevator in both oil mills. Differently from the first oil mill, in the second one leaves remover, washing machine, and crushing system are always activated contemporarily.

Figure 2. The oil mill in Noto (province of Syracuse).

At the exit, the olive paste is pumped inside the kneading machines; in the older oil mill, the crushing phase is finished by means of a rotating cutter with three blades installed at the end of the feed pipe. The kneading machines in the first oil mill consist in three modules and each module can be bisected so that its volume can be adequate to the amount of the worked batch. In the second oil mill they consist in six modules, equipped with an automatic pressurised washing system.

Finally, in both oil mills, oil extraction is performed by means of a horizontal centrifugal extractor, and water separation is carried out by means of two vertical centrifugal separators.

Measuring equipment

The measurements of the sound pressure levels were carried out by using a microphone RION, model UC-53A, screwed on a pre-amplifier RION, model NH-17A, connected to an amplifier MESA, model R31. A sound pressure calibrator NORSONIC mod. CAL1251, which provides a sinusoidal pressure signal of 10 Pa (114 dB) at the frequency of 1000 Hz, was used to calibrate the measuring chain. The microphone signals were recorded on the hard disk of a notebook by using a PC based recording and analysis system made up of a four-channel USB-II data acquisition unit (dB4), a PC, and the dBFA Suite software (01 dB-Metravib). With the software it is possible to configure the measuring chain, to carry out the calibration of the microphone by fixing its sensitivity and to start or stop the signal acquisition. Moreover, it allows for several post-processing analyses, among which narrow band analysis (FFT), 1/3 and 1/*n* octave analysis. The frequency weighting according to the different sound weighting curves provides the continuous equivalent sound pressure level L_{eq} for each signal analysed. Finally, the software allows studying both the full signal recorded, but also its fractions, so to analyse singular events.

The research activity

Noise measurements were carried out under ordinary working conditions in several points of both oil mills (Figure 3 and 4). As the oil mill in Regalbuto did not work at full capacity, noise signals were recorded in two different days.

The microphone was fixed to a tripod at the height of 1.5 m above the ground. In the first oil mill, due to the different plant layout and the irregular free space, the measurement points were preferably selected near the machines (Figure 3), but three points (R1, R4 and R7) were chosen in correspondence of the area where the workers operate and are more influenced by two or more machines.

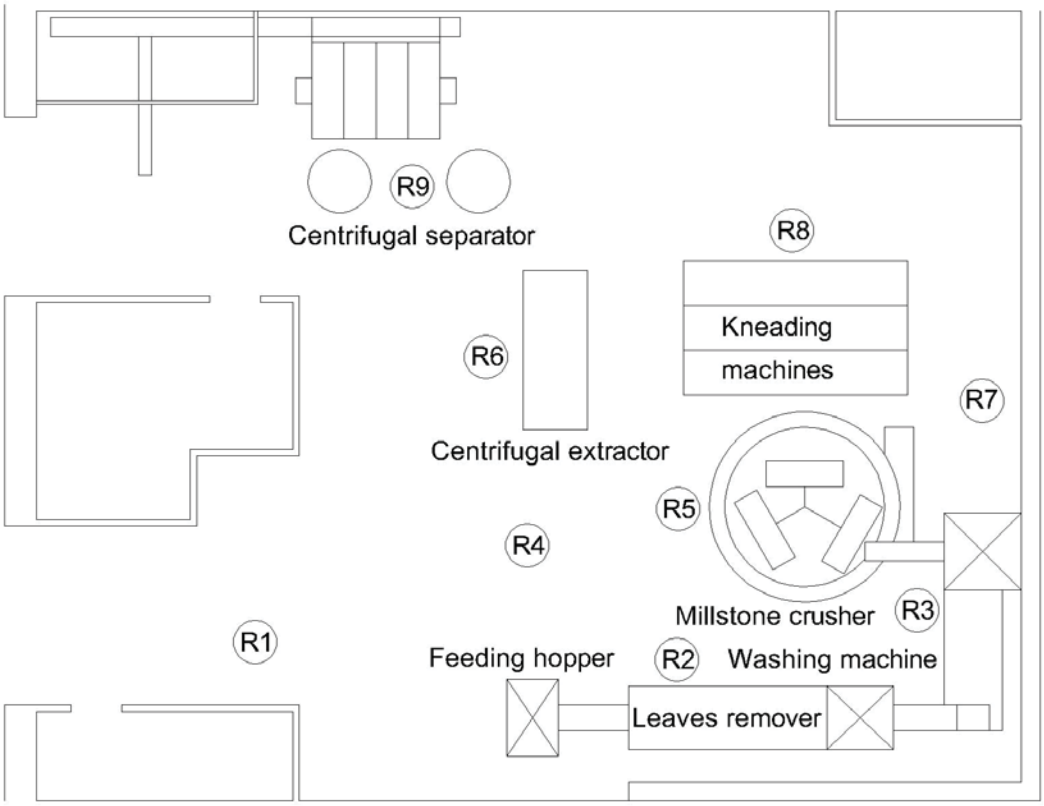

Figure 3. Plant layout and measurement points in the oil mill in Regalbuto.

In the second oil mill, ten measurement points were selected, disposed on a rectangular grid made by two lines 2 m apart and five columns 2.5 m apart (Figure 4). Another point (N11) was chosen near the general electric panel, where the operators may remain to start or stop a machine or to verify the regular functioning of the plant.

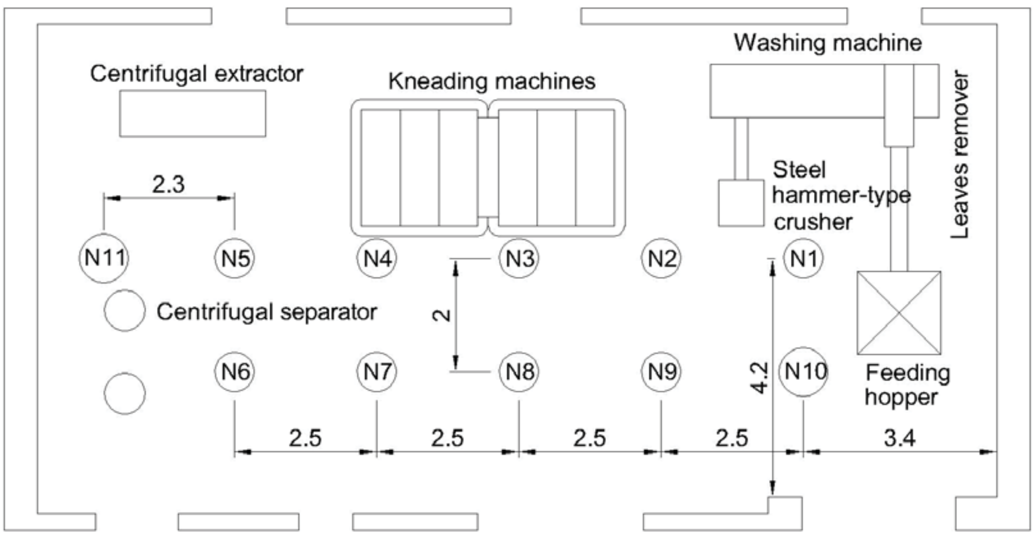

Figure 4. Plant layout and measurement points in the oil mill in Noto.

Each measuring session ranged from about 7 up to 37 minutes in the first oil mill and from about 5 up to 15 minutes in the second one, so to ensure the recording of a signal representative of the ordinary working conditions. During the measures all the significant variations (activation or deactivation of machines) were noted.

Data analysis

The signals were analysed in the range 0–20 000 Hz (third of octave bands from 12.5 Hz to 20 kHz) by applying the FFT and the 1/3 octave analysis and by computing the frequency weighted sound pressure levels (RMS values) and the continuous equivalent sound pressure levels weighted A L_{Aeq}. Then the exposure times T_e need to reach the superior action value of 85 dB(A) and the exposition limit value of 87 dB(A) of the daily personal exposition level $L_{EP,d}$, established by the Government Decree no. 81/2008, were computed by applying the equation:

$$L_{EP,d} = L_{Aeq,T_e} + 10\log_{10}\frac{T_e}{T_0},$$

being T_0 a reference exposure time of 8 hours.

To put in evidence the effect of single machines, first of all each signal was analysed in its entirety and then several sub-signals, concerning constant working conditions, were extracted from it and analysed separately.

Graphical representations were carried out by using the open source software *R*.

Results and Discussions

Looking at the signals recorded and taking into account the activations and deactivations of the machines noted during the measurement sessions, it was possible to easily identify the correspondent variations in the sound pressure levels. For example, in figure 5, concerning a measurement carried out in position N2 inside the second oil mill, during the first 35 s the signal was influenced by the pressurised system to clean the kneading machines; the peaks showed at around 180 s were due to the empting of a bin into the feeding hopper; at last, the new increasing of pressure after 225 s was caused by the activation of the leaves remover, the washing machine and the steel hammer-type crusher.

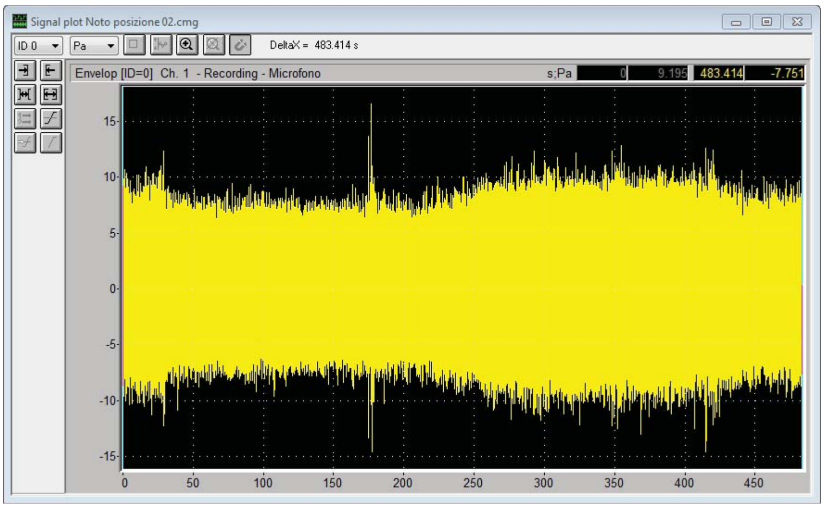

Figure 5. A signal recorded into the second oil mill.

The results of the analysis carried out on the full signals are showed in figures 6 and 7 for the two oil mills respectively. In the same graphs are reported the minimum and maximum values of the sound pressure level computed with reference to the sub-signals recorded in constant running conditions. Where the minimum and the maximum values are missing, it means that did not happen significant variations in the running conditions during the acquisition of the signal.

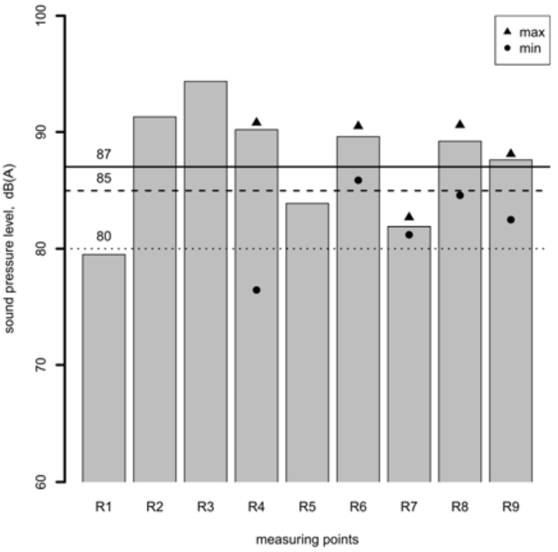

Figure 6. Sound pressure levels recorded in the oil mill in Regalbuto.

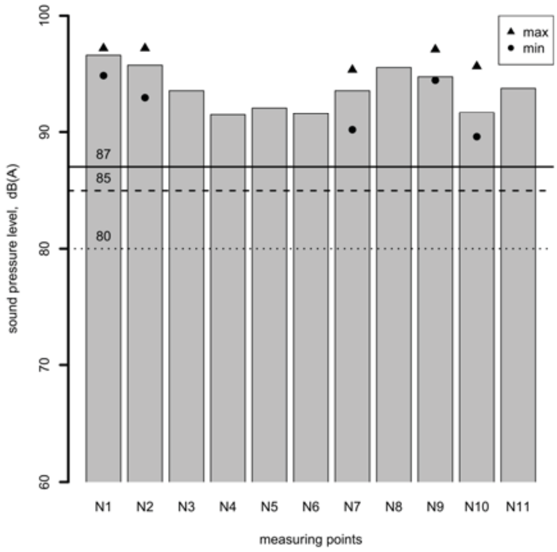

Figure 7. Sound pressure levels recorded in the oil mill in Noto.

In the first oil mill (Figure 6), the continuous equivalent sound pressure levels in each position were always higher than the threshold value of 80 dB(A), with the only exception of the position R1, the access area of the mill and the furthest by the plant, where, nevertheless, 79.5 dB(A) were measured. In R5 and R7 the continuous equivalent sound pressure levels were 83.9 and 81.9 dB(A) respectively, but during the recording the leaves remover was turned off. Furthermore, in R7 it was possible to detect the contribution of the transfer pump for the olive paste together with the crushing finisher (maximum value) and of the millstone crusher (minimum value), that was turned off for 14 minutes. In all the other measurement points the level was always exceeding the exposition limit value of 87 dB(A). In R4 it is possible to valuate the effect of the only millstone crusher (minimum value) and a difference of around 6 dB between maximum and minimum values in correspondence of R6, R8 and R9, mainly due to the leaves remover and the washing machine, in the proximity of which (R2 and R3) the highest values were recorded.

Looking at the second oil mill (Figure 7), that during the measuring sessions had a more continuous running with respect to the first one, values higher than 90 dB(A), with a mean of 93.7 dB(A), were recorded in all the points. Also in this case the main sources of the sound pressure level were the leaves remover and the washing machine, to which must be added the steel hammer-type crusher, noisier than the millstone crusher. Their contribution was again valuable by observing the difference between maximum and minimum values in all the measurement points. It ranged from 4 up to 6 dB in function of the activation of the leaves remover and the washing machine. Also the pressurised washing system of the kneading machines had some effect, but it was active only few seconds and can not provide a significant increase in the sound pressure level. The background level was associable to the centrifugal extractor, but it was not possible to determine its effect.

The higher sound pressure levels recorded in the second oil mill can not be explained with the different crusher system only and/or the running conditions of the mills (the first oil mill did not operate at full capacity and therefore the machines were always started and stopped). A great contribution was due to the size of the workroom and, above all, to its height, very larger for the first one. This circumstance could induce more reverberation in the second oil mill, so increasing the pressure level.

Given this working condition, the use of personal protection equipment (PPE) is absolutely mandatory. In fact, with the mean equivalent sound pressure level of 93.7 dB(A), the two limits of 85 and 87 dB(A) fixed by the regulation in force are achieved after only 1.7 and 1.1 hours respectively. These times are absolutely incompatible with the duration of the ordinary working day. Moreover, especially with a family management, the PPE are refused in order to hear anomalous sounds and preserve the plant. A solution could be found in covering the walls with sound absorption material and/or in shielding leaves remover, washing machine and crushing area.

Conclusions

The study allows for the following conclusions:

- The continuous equivalent sound pressure levels were quite high in both oil mills analysed. That located in Regalbuto showed a sound pressure level lower than the oil mill in Noto but, due to its running conditions, other measuring sessions should be carried out.
- The machines that more contributed were the leaves remover, the washing machine and the steel hammer-type crusher, but also the centrifugal extractor with its continuous noise can provide a high background sound pressure level.
- The size and the height of the workroom can have high influence due to the reverberation of the walls. To limit this effect could be necessary to cover the walls with sound absorption material.
- The mean value of 93.7 dB(A) recorded in the second oil mill causes the achievement of the limits fixed by the regulation in very short times: 1.7 and 1.1 hours respectively. The use of PPE is then essential, but they are refused by operators because of the necessity to hear immediately anomalous sounds to preserve the plant. It follows that more effective information on the effect of the noise on safety and health is absolutely necessary.

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