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Remigio Berruto · Marcello Biocca ·
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# Safety, Health and Welfare in Agriculture and Agro-Food Systems

## Ragusa SHWA 2023

Springer

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# Preface

Welcome to VII Ragusa SHWA Conference proceedings devoted to the Safety, Health and Welfare in Agriculture and Agro-food systems. This volume gathers the collective wisdom and insights of scholars in Occupational Safety, Agricultural Welfare and Rural Health, to face the challenge of achieving a safer, healthier, and more sustainable future for those who work the land.

The conference has been promoted by the Mechanics and Mechanization Section of the Di3A Department of the University of Catania under the auspices of the International Committee on Rural Engineering-CIGR-and the Italian Agricultural Engineering Association–AIIA.

The Ragusa SHWA 2023 International Conference followed the track of the previous editions held in Ragusa in the years 2008, 2010, 2012 and, in 2015, in Lodi in partnership with Rural Health, under the High Patronage of the Presidency of the Italian Republic.

As in previous editions, the morning of the first day of the conference was devoted to an Italian-language meeting. The workshop "Safety and Health in the Transformed Belt" was organized by the Department of Experimental Clinic Medicine of the University of Catania.

The importance of prioritizing workplace safety, rural health and welfare cannot be overstated in the vast landscape of agricultural life, where challenges are as diverse as the crops we grow and the animals we raise. It is a critical responsibility we owe to the hard-working individuals who dedicate their lives to nourishing our communities and supporting our economies.

This conference is not simply a platform for knowledge exchange; it is a testimony to the collective commitment to promoting human relationships built on the values of compassion, solidarity and mutual support. Through these connections, we find strength in unity, resilience in adversity, and hope in the face of challenges.

The 95 specialists attended in the disciplines relating to the topics covered by the conference, many of whom came from abroad (Denmark, Sweden, Greece, Germany, USA, Australia).

A total of 88 papers authored by 240 scholars were presented as oral presentations under the parallel sessions and symposia, and as poster presentations. All accepted abstracts were collected in the Book of Abstracts which can be accessed on the conference website, as well as the slides of the presentations.

The 54 papers selected for publication in this volume underwent a rigorous peer-review process carried out by more than 40 reviewers, assuring the high level of the scientific contribution of the papers of this volume.

Between the discussions, workshops and presentations, we also took moments to appreciate the serene beauty of the place that graciously hosted our meeting: Ragusa, a UNESCO heritage site.

The Ragusa SHWA conference has the distinctive characteristic of having always been held in cities of art; therefore, it shows a high rate of interest in the participants, and those who participate in one edition tend to return to subsequent ones. This means that the territory's opportunities are attractive and considered unique and authentic strengths. In particular, Sicily and its South-East constitute a real laboratory for actions related to agriculture, agri-food and well-being, in urban, coastal and rural spaces. All factors promote socialization, well-being and, ultimately, long-lasting and successful partnerships between researchers.

As we delve into the proceedings of this conference, we can be inspired by the dedication and passion of all who contributed to its success. From the organizers who meticulously planned every detail, to the speakers who shared their expertise, and the attendees who actively participated in enriching discussions. They played a crucial role in shaping the collective narrative of progress and innovation in agricultural welfare and rural health. Prof. Sabina Failla deserves special thanks for her outstanding work as the Scientific and Organizing Secretariat.

On behalf of the Organizing Committee, we express our heartfelt gratitude to all those who contributed to the realization of this Conference. Your ongoing commitment to promoting the well-being of agricultural communities is a beacon of hope for a brighter, healthier future.

The *Lectio Magistralis*, the Main Communication, and the oral and poster participants' contributions confirm that Ragusa SHWA conference has once again achieved its three main objectives: updating, crossing and encouraging to form new interdisciplinary research groups on safety, health and well-being.

Together, we continue to sow the seeds of change, cultivate a culture of safety and well-being, and reap the harvest of prosperity for all.

Finally, thanks to our esteemed speakers, sponsors and partners for their valuable contributions and unwavering support. Last but not least, we extend our heartfelt appreciation to all the participants whose active participation made this conference a genuinely enriching and memorable experience.

The International Conference Ragusa SHWA Organizing Committee will wait for you for the next 2025 online and 2026 in presence editions of the conference. Save the date and keep in touch by the web!


February 2024

Remigio Berruto
Marcello Biocca
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# Inhalable Wood Dust Produced During Chainsaw Operations

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**Abstract.** Wood dust produced during chainsaw operations can pose a significant risk to the health of workers. In this work, the wood dust total suspended particles (TSP), and the respirable fraction ($PM_4$) were sampled by active filtering with personal air samplers. Wood logs of three different species (*Eucalyptus* sp., *Pinus radiata* and *Quercus cerris*) were employed for the intense cross-cutting tests carried out in two separate trials (July and December). Some filter samples were undergone to chemical analysis to determine the contents of metals. Two chainsaws, one electric powered by batteries and one endothermic, were employed in the tests. Results showed that the different woods and the two chainsaws produced similar quantities of wood dust, that was characterized by a major fraction of fine particles $< 1$ µm. Obtained values of inhalable wood dust were very variable in values (in July's test, $PM_4$ ranged from 2.9 to 52.5 mg $m^{-3}$ and TSP from 3.7 to 42.6 mg $m^{-3}$; in December $PM_4$ ranged from 1.0 to 4.0 mg $m^{-3}$ and TSP from 3.2 to 5.8 mg $m^{-3}$). Values often exceeded the European legal threshold of concentration, and the operator should protect himself wearing a proper PPE (personal protective equipment). Moreover, attention should be paid to the exposure to wood dust and to heavy metal elements considering potential risks due to longer times of exposure that should be carefully evaluated. Among metals, nickel content was particularly elevated.

**Keywords:** Wood Particles · Health Risk · Heavy Metals · Cutting Practices · Nickel

## 1 Introduction

Many agroforestry practices produce inhalable inorganic or organic dust and workers can be exposed to high levels of airborne dust particles that have been associated to adverse health outcomes. For example, dust particles can be generated during soil tillage [1, 2], during harvesting operations [3] or it can be raised from not paved roads [4], from the abrasion of seeds coated with pesticides [5], from powdery pesticides products [6] such as sulfur [7] and from livestock rearing, especially in broiler and chicken farms [8].


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Wood is also a major dust source and wood dust can be generated during several practices, such as tree felling [9], chainsaw operations [10], pruning [11] or chipping operations [12].

Depending on particle size, dust is deposited either in the nasal cavity (< 100 μm), or in the respiratory tract below the larynx (< 10 μm), or in the alveolar region of the lungs (< 4 μm). Fractions smaller than 10 μm pose the greatest danger to the respiratory organs [13] Exposure to wood dust may cause respiratory and dermal symptoms and diseases and the risxk of developing cancer, mainly nose and sinus adenocancer [13, 14]. It has been estimated that 150,000 workers of the forestry sector can be exposed to wood dust in Europe (25 countries) [15].

The European Directive 2004/37 established an occupational exposure limit (OEL) of 5 mg $m^{-3}$ measured over a period of 8 h as an inhalable fraction. The same Directive was amended in 2017, lowering the limit to 2 mg $m^{-3}$, which is the current legal limit. Other agencies, such the Scientific Commission for Occupational Exposure Limits (SCOEL) of the European Union and the NIOSH (National Institute for Occupational Safety and Health) indicate even lower concentration limits.

Electric equipment, becoming more and popular in the last years, are reported as capable of emits minor levels of noise and vibrations, but no information is available regarding the amounts of dust that can be produced. This equipment is largely appreciated by arborists, especially for ergonomics reasons [16].

Furthermore, the dust particles can laden heavy metals and other substances (for example pesticides) with a resulting increase of the health and environmental risks [17–19]. Elements such as nickel, lead, cadmium and arsenic are considered carcinogenic and have been associated with DNA damage [20]. Italian legislation establishes exposure and objectives limits (for the general population) for arsenic (6 ng $m^{-3}$), lead (0.5 μg $m^{-3}$), cadmium (5 ng $m^{-3}$) and nickel (20 ng $m^{-3}$) (DM 60/2002 and D.Lgs. 152/2007).

The aim of this work was to assess the dust air concentration of wood dust produced during intense cross cutting chainsaw operations and its metal content.

## 2 Material and Methods

Two light chainsaws were employed in the cross-cutting tests: an endothermic one and an electric one powered by lithium batteries (Table 1).

In the trials of July (summer conditions), fresh wood logs of two different species (*Eucalyptus* sp. And *Pinus radiata*), 2.5 m long, with a diameter of 15–20 cm, were employed. Dry Pinus logs were also employed. In December (winter conditions), the tests were carried out cutting logs of *Quercus cerris* (about 20 cm of diameter) with only the endothermic chainsaw. In Table 2 some details of the trials are reported. In each test 100 cross-cuts were carried out of wood logs with a similar diameter (Fig. 1). Wood humidity was determined by re-weighing samples of wood after drying in a ventilated stove until constant weight.

At the beginning of the trials, a new cutting chain was mounted on the chainsaws. The cutting was carried by a professional operator who continuously cut wood disks (Fig. 1). Micrometeorological conditions were continuously monitored during the trials

**Table 1.** Characteristics of the chainsaws used in the tests.

| Characteristics | Chainsaws | |
|---|---|---|
| Brand | Stihl | Pellenc |
| Model | MS 201TC | C21HD |
| Engine Displacement ($cm^3$) | 35.2 | 45.0* |
| Power supply | Petrol | Electric – battery |
| Power (kW) | 1.8 | 2.0 |
| Max recom. Engine speed ($min^{-1}$) | 10.500 | 6.200 |
| Fuel reservoir volume (L) | 0.30 | – |
| Oil reservoir volume (L) | 0.22 | 0.25 |
| Oil pump type | Adjustable flow | |
| Chain pitch (mm) | 9.5 | 6.35 |
| Guide bar length (mm) | 350 | 280 |
| Ac. Pressure (A weighted), dB(A) | 100 ± 2.5 | 85 |
| Ac. Power (A weighted), dB(A) | 113 ± 2.5 | 100 |
| Vibration front/rear (mm $s^{-2}$) | 3.5/3.1 | 2.5/2.5 |
| Mass without cutting group (kg) | 3.7 | 2.6 |

* Displacement of an internal combustion engine chainsaw with equivalent performance, according to the data sheet.

with a portable weather station (Kestrel 4500). The tests have been conducted in the absence of wind.

Personal air sampler placed on the chat of the operator were employed for the sampling of the particulate matter. The characteristics of the instruments used in the trials are showed in Table 3.

**Table 2.** Details of the trials.

| Tests | July | December |
|---|---|---|
| Air sampling | Inhalable (TSP) and respirable ($PM_4$) | |
| Chemical analyses | Metallic elements | – |
| Chainsaw | Electric & combustion | Only combustion model |
| Operators | 1 professional worker | |
| Activity | Continuous cross cutting (100 cuts) | Continuous cross cutting (3 × 100 cuts) |
| Trunk size | Diam.: 15–20 cm; Length: 2.5 m | Diam: 30–35 cm; Length: 2.5 m |
| Tree species | *Pinus radiata, Eucalyptus globulus* | *Quercus cerris* |

**Fig. 1.** View of the cutting operations and resulting slices of wood.

**Table 3.** Details of instruments used in the trials.

| Measurement | Parameter | Instrument |
|---|---|---|
| Atmospheric conditions | Temperature, R.H., Wind speed, Atmospheric pressure | Portable weather station Kestrel® 4500 |
| Air sampling | Inhalable (TSP) and respirable ($PM_4$) particulate matter | Isokinetic personal air sampler "Zambelli Egoplus-TT" with 37 mm diameter, PTFE filters "Merck – Millipore" Sampling heads: conical inhalable sampler and Dorr-Oliver |
| Gravimetric and chemical analyses | Filters | Analytical balance "Sartorius ME5" (Resolution 0.001 mg; Max. Weight: 5.1 g) |
| | Filter mineralization | Microwave Assisted Acid Digestion |
| | Metallic elements | ICP-MS, method UNI EN ISO 16967:2015 |

## 3 Results and Discussion

The wood humidity of logs employed in the July tests ranged from 14.5% of the dry pine, to 48.3% of eucalyptus and 55.5 of the fresh pine. Micrometeorological conditions of the summer test were extreme in terms of air temperature (41 °C) and air relative humidity (35%). During the December trial, air temperature was 11.6 °C in average and air relative humidity 65%. In this test, Turkey oak logs with a humidity of 34% were employed.

The concentrations of particulate matter in atmosphere during the July tests are reported in Fig. 2. The values are extremely high and variable, especially for $PM_4$. Even the blank (control) sample, collected with a sampler for the $PM_4$ and placed far from the trial area, was particularly high (1.2 mg $m^{-3}$). A possible explanation for the high dust values could be the air temperature. Sometimes, local ascending air currents are likely to have caused the raising and the floating of the dust above the ground, in the proximity of the air samplers [21].

In July, a comparison of dust produced by the two chainsaws showed that the equipment produced similar amounts of dust, in terms of average between TSP and $PM_4$ (Fig. 3). The same comparison (average of TSP and $PM_4$) performed among the different woods, also showed no differences (Fig. 3). This result contrasted with previous works [22].

Filter samples collected in July underwent chemical analyses for metal content. The amount of the analyzed elements decreased as follows: Na > K > Al > Fe > Ca > Mg > B > Cu > Cr > Zn > Ni > Pb > Mn > Co > Li > Tl > Ag > As > Cd > Be. Among the elements for which there is a legal concentration limit in the air, cadmium was not detected at the limit of quantification (<LoQ), and lead and arsenic were under the legal limit of exposure. However, nickel, that showed an average concentration of 16.2 mg $m^{-3}$ in $PM_4$ and 4.16 mg $m^{-3}$ in TSP, exceeded limits in many repetitions. Overall, comparing contents with blank values, high values of nickel (Ni) and iron (Fe) occurred. Likely they derived from the wear of the chain of the chainsaws which may have lost more than 150 mg of weight during the test (Fanigliulo *et al.*, unpublished data).

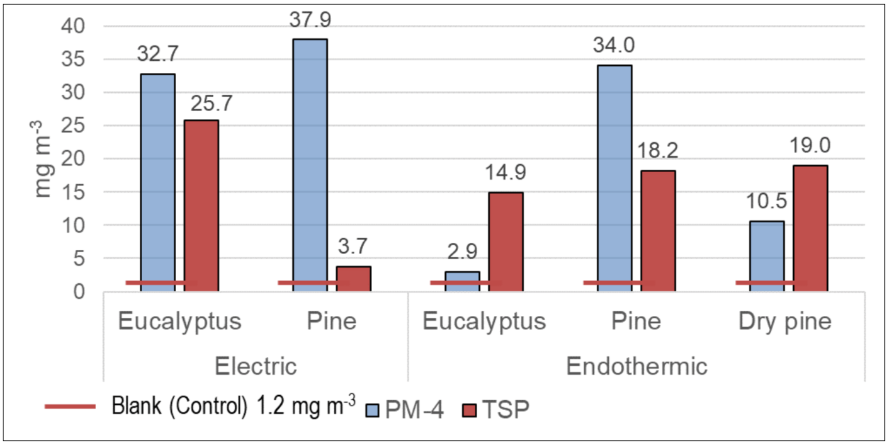


**Fig. 2.** Air dust concentrations (mg $m^{-3}$) during the July tests.

The results of December trial (winter conditions) are reported in Fig. 4, where the minimum and maximum values are also shown. Also in this test, the air concentrations exceeded the legal limit. Although that the relative humidity was higher than in the summer trial, the values of concentrations are more similar to those reported in other works [9, 10] (Table 4).

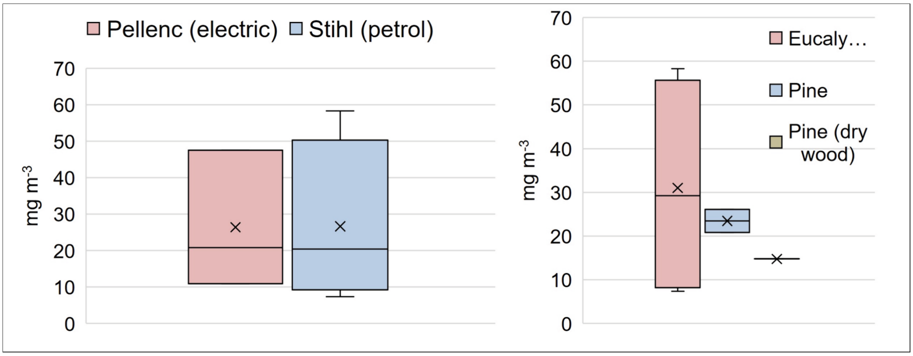


**Fig. 3.** Average of respirable and TSP in mg m$^{-3}$ by the chainsaws (number of samples = 14) (on the left); average of respirable and TSP by the wood (on the right).

**Table 4.** Metal content in the filter samples in mg m$^{-3}$. Elements for which there is a legal limit of exposure are marked in bold.

| Element | $PM_4$ | TSP | Blank ($PM_4$) |
|---|---|---|---|
| **Pb** | **3.17** | **1.28** | **0.16** |
| Tl | 0.61 | 0.25 | 0.01 |
| **Cd** | **< LoQ** | **< LoQ** | **< LoQ** |
| Ag | 0.10 | 0.01 | 0.00 |
| **As** | **0.02** | **0.00** | **0.00** |
| Zn | 11.68 | 8.68 | 0.64 |
| Cu | 28.09 | 10.50 | 1.44 |
| **Ni** | **16.20** | **4.16** | **0.50** |
| Co | 2.78 | 1.30 | 0.10 |
| Fe | 85.74 | 34.54 | 2.09 |
| Mn | 2.81 | 1.41 | 0.13 |
| Cr | 14.15 | 6.49 | 0.53 |
| Ca | 64.44 | 38.83 | 3.56 |
| K | 717.25 | 374.96 | 36.81 |
| Al | 200.67 | 44.09 | 11.22 |
| Mg | 51.03 | 30.67 | 3.60 |
| Na | 1433.56 | 739.57 | 83.79 |
| B | 39.44 | 19.30 | 2.16 |
| Be | <LoQ | <LoQ | <LoQ |
| Li | 2.09 | 1.04 | 0.11 |

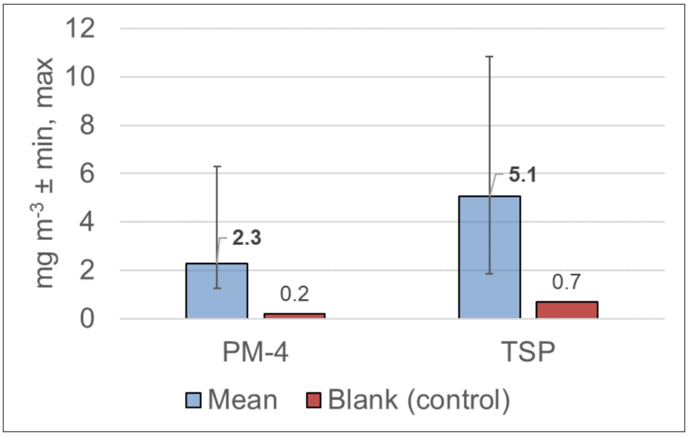


**Fig. 4.** Air dust concentrations (mg $m^{-3}$ ± min and max) during the December tests.

## 4 Conclusions

In this work the potential occupational exposure risks to wood dust were investigated. This subject is largely studied during operations carried out indoor, mainly related to the sawing of fresh and stored wood and in the furniture industry. However, exposure can occur also during practices carried out in open air.

The results showed that even in this condition, air-borne particles concentration values frequently exceeded the European legal thresholds. As a consequence, the operators should protect themself wearing proper PPE (personal protective equipment), especially in case of long times of exposure. Furthermore, it was noted that wood cutting can produce major amounts of very fine particles, potentially more harmful for human health.

To our knowledge, in this paper it was reported for the first time that nickel is contained in the wood dust at a level that can cause health hazard. It was rather clear that the wear of the equipment chainsaw largely contributed to the nickel contamination.

The comparison of the two chainsaws carried out in the July's trials showed that (in average) they produced similar amounts of dust and no substantial differences were recorded cutting the different type of wood.

Further investigations shall include an extension of investigations on dust production in different environmental conditions, to better understand the relationships between humidity and temperature on dust deposition.

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# Evaluation of Noise Emissions and Cutting Performance of Chainsaws for Small Scale Forestry Operations

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**Abstract.** Exposure to high levels of noise over time can cause effects on the health of operators. Furthermore, the use of chainsaws in urban areas during the maintenance of urban vegetation, contributes to the noise pollution in cities. This paper reports the results of tests carried out with the aim of evaluating the levels of exposure to noise caused by three light chainsaws for pruning (two electric powered and one with an endothermic engine) and two pole chainsaws (one electric and one endothermic). The equipment was tested in cutting operations of fresh hardwood and softwood logs of different species. The acquisition of sound pressure values was carried out according to the Italian Legislative Decree 81/08, using a certified instrumental chain. The measurements were performed with the equipment in three different conditions: engine at idle (only for the internal combustion one), at maximum and during cutting. To evaluate the cutting performance, the cutting times were measured taking into account the diameter of the wood samples, then expressing the results in seconds $cm^{-2}$. The results showed that the tested electric chainsaws, during cutting, have comparable noise emission and cutting velocity, while obviously those of the petrol chainsaw are much higher. A significant difference was found in the average dB(A) values, considering both types of woods used, between the two electric chainsaws. However, electrical equipment also showed high levels of noise emissions that must be considered in calculating the daily exposure levels (LEX, 8 h), according to Italian law (Legislative Decree 81/2008).

**Keywords:** Work Safety · Urban Forestry · Hazardous Physical Agents

## 1 Introduction

In agriculture and forestry, the use of motorized equipment results in the exposure of workers to hazardous physical agents such as noise, hand-arm vibrations, exhaust gases, and wood dust. Furthermore, chainsaw use is linked to high rates of accidents, both in professional and non-professional work [1].


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The recurrent or continuous exposure to noise causes several types of occupational diseases. This risk is usually underestimated by workers because it is perceived as not hazardous to human health. However, occupational diseases in agriculture and forestry are constantly increasing in the last years in Italy, especially for musculoskeletal disorders and, to a minor rate, for noise-induced hearing loss [2].

Noise-induced hearing loss can be caused by short exposures to extremely high sound levels or by repeated exposures to moderate levels. This can lead to a temporary or permanent loss of sensitivity and acuity. Furthermore, noise incites a stress reaction in the human body that can potentially lead to premature death, cardiovascular disease, cognitive impairment, sleep disturbance, hypertension and, at the least, annoyance [3].

The fundamental regulatory Italian law in the matter of prevention from noise and vibrations risks is Legislative Decree 81/2008. In particular, the Decree establishes three limit levels of noise exposure (80, 85 and 87 decibels – dB (A)) and the corresponding obligations to which workers are required if the levels exceeded. Other international standards (ISO 1999:1990; NIOSH revised criteria, 1998) recommended the equivalent sound pressure level ($L_{equ}$, 8h) of 85 dB(A) (A filter-weighted, 8-h working day-weighted average) as the exposure limit for occupational noise.

The use of electric equipment, instead of traditional endothermic chainsaws, results in the most direct way to reduce exposure to noise (and exhaust gas emissions and vibrations). In the last years the use of these equipment has grown hand in hand with the increase of their performance, especially at the level of batteries performance. In a survey carried out among tree-climbers, the 50% of participants declared that they use always (25%) or often (25%) electric chainsaws for tree pruning [4].

Comparison studies between electric and endothermic chainsaws have clearly shown lower emissions of noise in electric chainsaws [5–7].

In urban forestry, a great advantage is provided by battery chainsaws, specifically in pruning operations. Beside the benefits in terms of reductions of noise and vibrations, electric chainsaws give advantage in terms of ergonomics, especially to the climber arborists who operate in uncomfortable conditions. They found particularly important the reduced weight and the engine starting (a button instead of the recoil starter). However, the employ of electric chainsaws is still limited in operations where bigger cuts are required, such as the major tree felling [8]. Furthermore, the use of electric equipment in urban areas contribute to the reduction of the city noise pollution.

The aim of this work was to assess performance of electric and petrol-powered equipment and to estimate the level of their noise emissions.

## 2 Materials and Methods

Three light chainsaws (Fig. 1), and two pole saws (Fig. 2) were compared for their cutting performances and noise. Table 1 shows the main characteristics of the tested equipment.

Chainsaws were tested in cross cutting operations of fresh wood logs (diameter 12–16 cm) of hardwood (*Eucaliptus* sp.) and softwood (*Pinus halepensis*). The pole saws were tested cutting the basal branches of living trees of *Tilia* sp. And *Cedrus atlantica.* Wood samples were heated in stove up to constant weight to determine the humidity of the wood.