Ergonomic parameters of the work of integrated technologies at timber harvesting

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Abstract – Nacrtak

The trend of fully mechanized timber harvesting with harvester technologies requires the evaluation of ergonomic parameters of workers' activities and the impact of machine technologies on natural environment. The aim is to prove the need of modernization of harvesting-transport process in forests because of a big amount of reserves in fields of effectiveness, ecology and safety and health protection at work. In this work, the noisiness of integrated technology of harvester FMG 990 Lokomo and forwarder Timberjack 1110D in the relation with the distance and working operation was evaluated. Besides this, dosimetric measurements of noise stress of the operator of harvester and forwarder were performed. Following these data, 8 hours noise exposition of workers was calculated and these were compared with maximal allowed values that are assessed by the valid legislative of Slovak Republic.

Key words: *noise, harvester, forwarder*

1. Introduction – *Uvod*

The interest in technical development of forestry in Europe is growing very significantly. It is connected with growing of human work costs and with society efforts of eliminating health risks, ensuring sustainable forest management, retaining forest production capacities, ensuring fluency of production with the help of multioperational machines. In many cases, the technique simplifies and makes physically demanding working actions easier and fastens the work. One of possible solutions, how to satisfy these requirements, is the employment of harvester technologies, because these machines work with high productivity, low costs on produced assortment, they work regarding the soil and trees in the stand, ergonomically favorably with low injury share. On the other hand, there are high requirements on the machine operator because of the neuro-psychical load, vibrations and noisiness (Sherwin et al., 2003, 2004).

2. Work material and methods – *Materijal i metode*

At measuring of harvester noise we proceeded according to directions for measuring and evaluation of noise exposition in work environment (STN ISO 9612). This international norm provides the general guide, what types of measurements in which areas are required for the evaluation of noise considering its impact on a worker to follow the coincidence with established rules and to indicate the need of noise decreasing by antinoise arrangements.

Measuring of harvester operator charge was performed according to the norm STN 470176-1 »Methods of measuring of noise in the environment of the operator«, which involves agricultural and forestry machines and assesses technical methods of noise measuring in the environment of the operator. The measuring was performed in the cabin of the harvester. Measuring of forwarder operator charge was performed according to the same norm.

We used the Norsonic Nor 118 noisemeter at our measuring. The Norsonic Nor 118 noisemeter is a hand-held measuring tool designed for measuring of noise in working and living environment. It matches following norms: EN IEC 60651, EN IEC 60804, ANSI S.14A type 1, ANSI S1.43, DIN45657.

3. Results – *Rezultati*

3.1. Results from measuring of noise of the harvester FMG 990 Lokomo – *Rezultati izmjere buke harvestera FMG 990 Lokomo*

The harvester FMG 990 Lokomo noise was measured in the forest stand no. 415 of the forest admin-

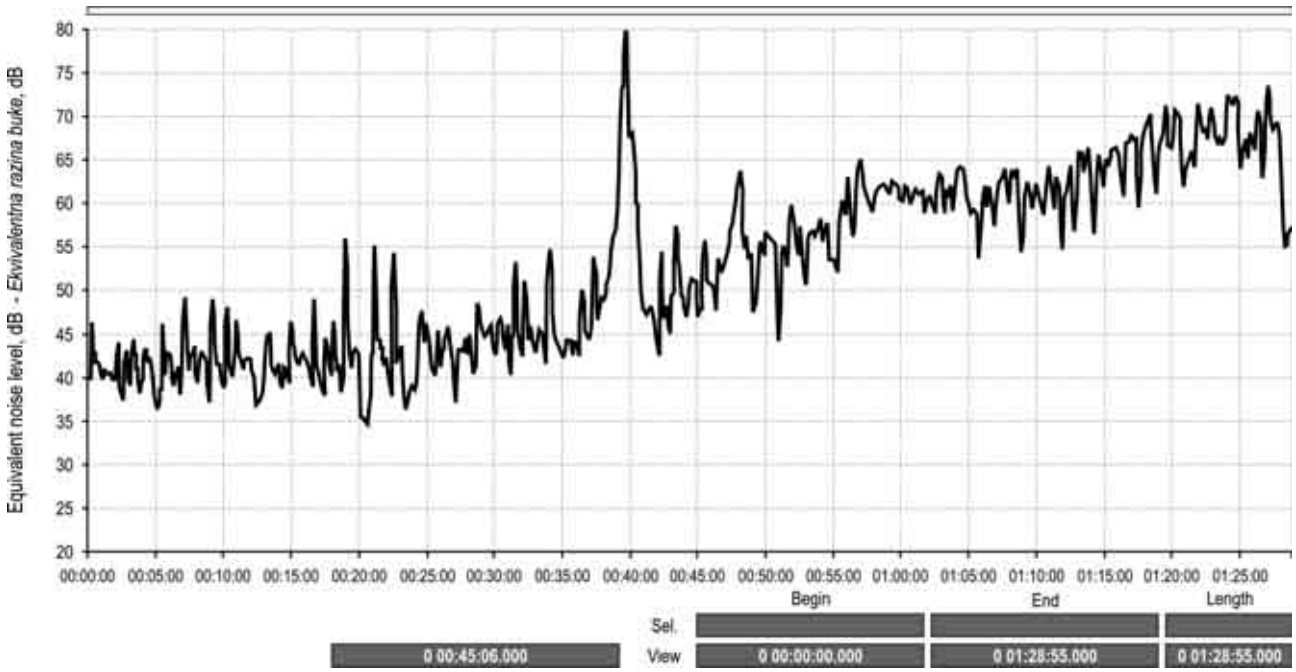

Figure 1 Graphic representation of the continuance of noise equivalent level (L_{Aeq}) during measuring
Slika 1. *Grafički prikaz neprekidnosti ekvivalentne razine buke (L_{Aeq}) tijekom mjerenja*

istration Mikulášov of the Military forests and estates, which acreage is 4.42 hectares, age is 95 years, mean stand height is 24 meters and mean tree thickness is 0.34 m. There is the tree composition 100 % of Scotch pine at the stocking of 0.79 in the stand and the entire standing volume is 980 cubic meters. Measured values of harvester noise are shown in graphs and tables that were processed with the software Noreview. The input data was the measuring of noise continuance on workplaces at harvester work. The measuring lasted 1 hour and 29 minutes. It is possible to see growing equivalent level of noise with oncoming machine to the measuring spot on the Figure no. 1.

Table 1 The values of noise equivalent level (L_{Aeq}) in the relation with distance

Tablica 1. *Vrijednosti ekvivalentne razine buke (L_{Aeq}) u odnosu prema udaljenosti*

Distance, m *Udaljenost, m*	Work duration, min *Trajanje rada, min*	L_{Aeq}, dB
250	20:30	43.1
200	9:30	54.8
150	14:34	58.6
100	15:30	58.4
50	15:00	62.0
25	14:00	68.1
Total – *Ukupno*	1:29:00	63.8

In the Table 1 the continuance of noise equivalent level (L_{Aeq}) during measuring at machine work in distances 250, 200, 150, 100, 50, 25 meters is shown.

The equivalent noise level (dB) for five tipical harvester work components in relationship to the

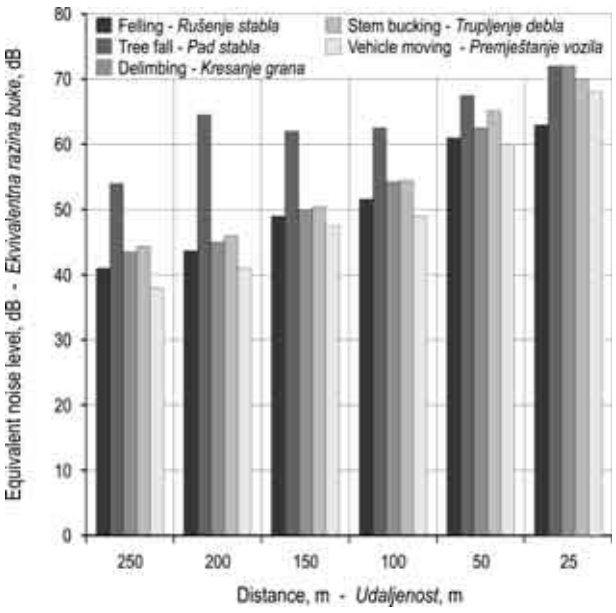

Figure 2 Graphic representations of values of noise equivalent level (L_{Aeq}) at working operations in various distances

Slika 2. *Grafički prikaz vrijednosti ekvivalentne razine buke (L_{Aeq}) pri radnim operacijama na različitim udaljenostima*

Table 2 Resultant noise levels
Tablica 2. *Rezultantna razina buke*

Parameter *Mjerna veličina*	Noise level, dB *Razina buke, dB*	Percentual level *Postotna razina*	Noise level, dB *Razina buke, dB*
L_{Aeq}	63.7	$L_{0.1}$	85.8
L_{Aleq}	67.0	L_1	74.1
L_{AFmax}	89.4	L_5	68.6
L_{AFmin}	30.8	L_{10}	65.5
$L_{Ceq}-L_{Aeq}$	9.2	L_{50}	50.8
L_{Ceq}	72.9	L_{90}	39.0
L_{CFmax}	97.3	L_{95}	37.5
L_{Cpeak}	106.8	L_{99}	34.1

working distance is graphically represented in Figure 2.

The resultant analyses of the noise level parameters in harvester work environment is given in Table 2.

3.2. Results of dosimetric measurements of harvester operator noise charge during working shift – *Rezultati dozimetrijskoga mjerenja buke koja utječe na vozača harvestera tijekom radne smjene*

On the Figure 3 there is shown the continuance of equivalent and maximal noise level (L_{Aeq}, L_{Amax}) during measuring in the cabin of the harvester, which lasted for 36 minutes.

It can be seen from the Figure 3 that the highest noise values are reached at machine movement, what is caused by higher engine operating speed. Significant noise differences at single working operations were not registered because the cabin was well silenced. From 22nd minute and 45th second the ventilation was switched on what resulted in equalization of noise level in the cabin.

While the ventilation was switched off, the L_{Aeq} reached 69.0 dB, while the ventilation was switched on, the L_{Aeq} reached 72.7 dB. Resultant noise levels of all parameters that were measured in the harvester cabin are presented in the Table 3.

Table 3 Resultant noise levels of measured parameters
Tablica 3. *Rezultantne razine buke mjerenih veličina*

Parameter *Mjerna veličina*	Noise level, dB *Razina buke, dB*	Percentual level *Postotna razina*	Noise level, dB *Razina buke, dB*
L_{Aeq}	69.9	$L_{0.1}$	82.1
L_{Aleq}	73.8	L_1	77.0
L_{AFmax}	86.1	L_5	73.2
L_{AFmin}	47.9	L_{10}	72.8
$L_{Ceq}-L_{Aeq}$	18.3	L_{50}	67.8
L_{Ceq}	88.2	L_{90}	63.8
L_{CFmax}	108.9	L_{95}	62.5
L_{Cpeak}	116.3	L_{99}	57.3

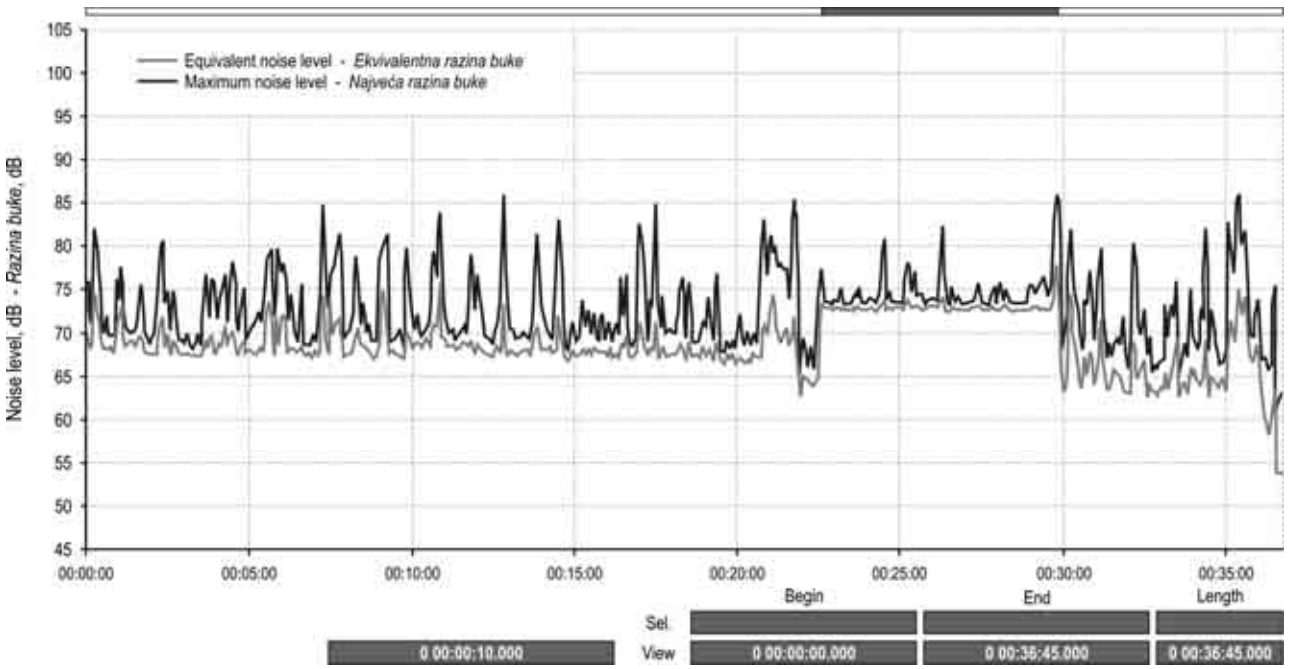

Figure 3 Continuance of L_{Aeq} and L_{Amax} in the cabin of the harvester
Slika 3. *Neprekidnost L_{Aeq} i L_{Amax} u kabini harvestera*

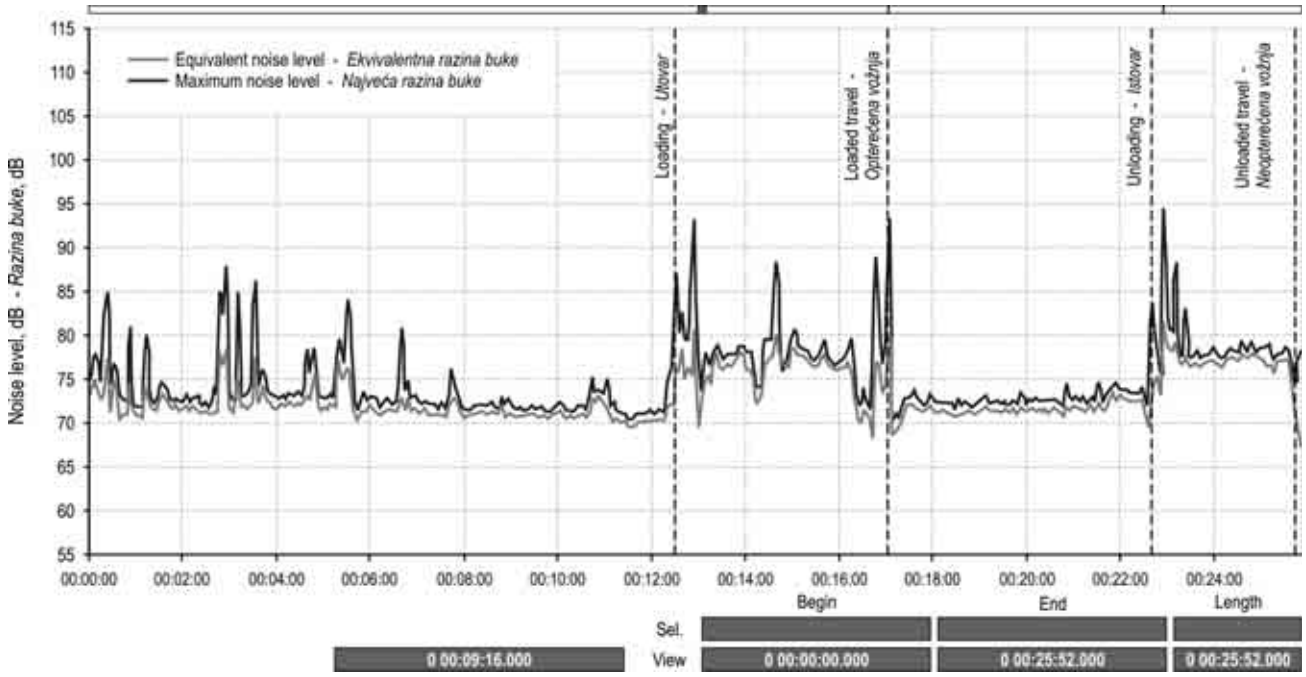

Figure 4 Continuance of L_{Aeq} and L_{Amax} during one working cycle
Slika 4. *Neprekidnost L_{Aeq} i L_{Amax} tijekom jednoga radnoga ciklusa*

3.3. Results of dosimetric measurements of forwarder operator noise charge during working shift – *Rezultati dozimetrijskih mjera buke koji utječu na vozača forvardera tijekom radne smjene*

On the Figure 4 there is shown the continuance of equivalent and maximal noise level (LAeq, LAmax) during measuring in the cabin of the forwarder, which lasted for 25 minutes and 52 seconds (working cycle).

The comparison of equivalent and maximal noise level at single working operations is presented on the Figure 5.

Table 4 Values of maximal and equivalent noise level
Tablica 4. *Vrijednosti maksimalnih i ekvivalentnih razina buke*

Work components *Radne sastavnice*	Percentual share *Postotni udio*	$L_{Aeq,\ dB}$	$L_{Amax,\ dB}$
Loading *Utovar*	47.1	72.2	73.7
Loaded travel *Opterećena vožnja*	16.9	76.4	78.8
Unloading *Istovar*	21	71.9	73.8
Unloaded travel *Neopterećena vožnja*	15	77.1	78.9

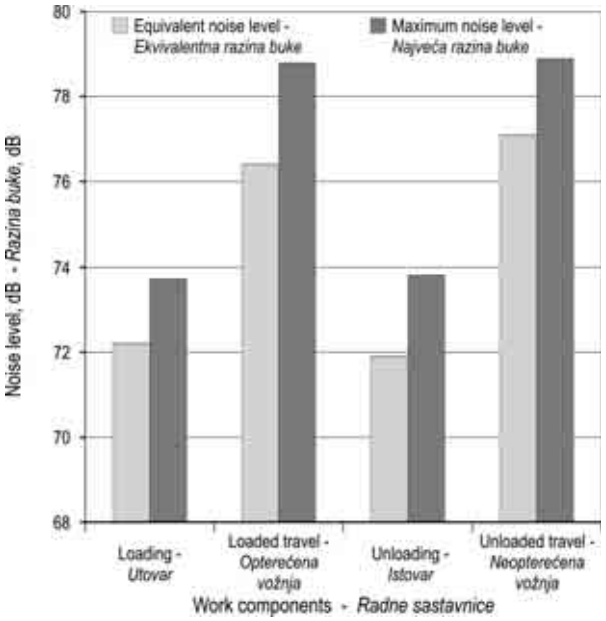

Figure 5 Comparison of the maximal and equivalent noise level
Slika 5. *Usporedba maksimalnih i ekvivalentnih razina buke*

During the entire measuring the equivalent noise L_{Aeq} = 74 dB was recorded. The operator worked with the forwarder for 6 hours and 30 minutes during the working shift. Resultant analyses of noise of measured parameters in the forwarder cabin are presented in the Table 5.

Table 5 Resultant analyses of noise of measured parameters in the forwarder cabin

Tablica 5. *Rezultantne analize buke mjerenih veličina u kabini forvardera*

Parameter *Mjerena veličina*	Noise level, dB *Razina buke, dB*	Percentual level *Postotna razina*	Noise level, dB *Razina buke, dB*
L_{Aeq}	74.0	$L_{0.1}$	86.3
L_{Aleq}	77.4	L_1	79.2
L_{AFmax}	94.2	L_5	77.8
L_{AFmin}	65.0	L_{10}	77.2
$L_{Ceq}-L_{Aeq}$	14.9	L_{50}	71.8
L_{Ceq}	88.9	L_{90}	70.4
L_{CFmax}	120.2	L_{95}	70.0
L_{Cpeak}	131.6	L_{99}	68.1

4. Discussion and conclusion – *Rasprava i zaključci*

If we compare measured values of equivalent noise level with values referred by the Timberjack machine producer, we will find out that measured values are lower than referred values. It is caused by the fact that the value of noisiness referred by the producer is the value at maximal engine operation speed and at different terrain conditions than those in Záhorie lowlands.

During the analysis of results of measured noisiness of the harvester and forwarder the difference of approximately 4 dB was detected. Measured equivalent noise level at harvester work was 69.9 dB and at forwarder work 74 dB. The difference can be explained by the fact that during work, forwarder is moving more often and faster than harvester. That means that the engine operation speed and power are higher and this fact causes higher noisiness in the cabin.

We have to state that the highest allowed values of noisiness on a workplace, which are assessed by actual legislative, were not exceeded in any case. That means that the highest allowed values of noisiness in cabin (80 dB for harvester and forwarder) were not exceeded neither.

Fast technical development enabled the producers to lower the level of noise at harvester and forwarder technology under the maximal allowed value, which causes the hearing injury. Every single producer tries to lower unwanted impacts of working machines on psychical and physical health of workers. The analysis of measured values shows the fact that the harvester technology in conditions of Military forests and estates Malacky is very appropriate from the point of view of ergonomics and especially noisiness, because it charges workers much less than the chainsaw or skidder. Their noisiness highly exceeds allowed values and can cause hearing injury sometimes. It is also very important to evaluate the impact of the other factors, such as neuro-psychical load and vibrations. Especially these factors impact the length of work and pauses and that is why it is important to keep the working discipline and by this to prevent injuries and work diseases. Further research focused on work ergonomics and noisiness as its part is necessary.

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STN 01 1603 Hluk. Metódy merania

STN 47 0176 Metódy merania hluku v mieste obsluhy (pre poenohospodárske a lesnícke stroje a traktory).

STN ISO 9612 Pokyny na meranie a hodnotenie hlukovej expozície v pracovnom prostredí.

Sažetak

Ergonomski parametri pri radu harvestera i forwardera

Buka u radnom okolišu raste s povećanjem primjene tehničkih rješenja te postaje neprihvatljiva mnogostruko prekoračujući dopuštene granične vrijednosti sigurnoga i zdravoga rada.

Trend potpunoga mehaniziranja pridobivanja drva harvesterskom tehnologijom zahtijeva procjenu ergonomskih čimbenika radnih aktivnosti te utjecaj strojnoga rada na prirodni okoliš. Cilj je pokazati potrebu za mehaniziranjem procesa pridobivanja i prijevoza drva u šumarstvu s obzirom na velike mogućnosti napretka u području učinkovitosti, ekologije te sigurnosti i zaštite zdravlja na radnom mjestu.

U ovom je prilogu istraženo opterećenje bukom pri radu harvesterom i forvarderom. Mjerena je buka harvestera FMG 990 Lokomo tijekom rada s obzirom na udaljenosti vožnje i radne zahvate. Također su obavljena dozimetrijska mjerenja opterećenja bukom vozača harvestera i forvardera Timberjack 1110D. Na osnovi rezultata dobivenih mjerenjima izračunata je izloženost radnika buci tijekom osmosatnoga radnoga dana i uspoređena s dopuštenim graničnim vrijednostima određenima trenutno važećom legislativom Republike Slovačke. Mjerene su vrijednosti obrađene i grafički prikazane uz pomoć programskoga paketa Norsonic.

Analizom rezultata mjerenja buke harvestera i forvardera utvrđena je razlika od oko 4 dB. Mjerena ekvivalentna razina buke harvestera u radu iznosila je 69,9 dB, a forvardera u radu 74 dB. Razlika se može objasniti učestalijim i bržim kretanjem forvardera tijekom rada u odnosu na harvester. Dakle, veće su brzine rada i snaga motora forvardera, što uzrokuje veću razinu buke od one izmjerene u kabini harvestera.

Potrebno je naglasiti da nisu prekoračene dopuštene granične vrijednosti buke na radnom mjestu određene aktualnim zakonskim okvirima. Najveća dopuštena razina buke u kabini harvestera i forvardera iznosi 80 dB i ni u jednom slučaju nije prekoračena.

Brz je tehnološki razvoj omogućio proizvođačima da smanje razinu buke u harvesterima i forvarderima ispod dopuštenih graničnih vrijednosti te tako smanje izloženost radnika mogućim oštećenjima sluha. Svaki proizvođač nastoji smanjiti štetne utjecaje radnih strojeva na psihičko i fizičko zdravlje radnika. Analiza rezultata mjerenja provedenih na području Vojnih šuma (Military forests) i posjeda Malacky dokazuje pogodnost harvesterske tehnike s ergonomskoga stajališta, posebice s obzirom na buku, jer radnika opterećuje u puno manjoj mjeri nego motorna pila ili zglobni traktor. Razina buke tijekom rada s motornom pilom i zglobnim traktorom uvelike nadmašuje dopuštene granične vrijednosti i može voditi oštećenju sluha. Također je važno utvrditi i utjecaj ostalih čimbenika, kao što su neuropsihološko opterećenje i vibracije. Navedeni čimbenici u značajnoj mjeri utječu na trajanje rada i odmora, zbog čega je važno održavati radnu disciplinu kako bi se izbjeglo ozljeđivanje radnika i profesionalne bolesti. Potrebna su daljnja istraživanja s naglaskom na ergonomiju, posebice opterećenje radnika bukom.

Ključne riječi: *buka, harvester, forvarder*

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