Influence of Selected Meteorological Phenomena on Work Injury Frequency in Timber Harvesting Process

Jozef Suchomel, Katarína Belanová

Abstract – Nacrtak

The aim of this article is to analyze the impact of the chosen meteorological phenomenon on the frequency of work accidents in the logging process in the Slovak forest sector. The article further evaluates the number of specific types of injuries, variations and sources of work accidents. Rain was the most frequently recorded meteorological phenomenon in the occurrence of accidents. Besides rain most injuries and wrenches were recorded on slippery surface and fractures occurred mostly during snowfall or in the presence of snow cover. Slips and falls were mostly recorded during rain as well as on slippery surface without the presence of any meteorological phenomena. The methods of analysis, synthesis and comparison were used In preparing this paper.

Key words: forestry, forestry work, work safety, injuries, weather, meteorological phenomena

1. Introduction – *Uvod*

The significance of weather and climate can be recognized for both biotic and abiotic organisms on Earth including humans. Weather and climate are important factors that influence labor productivity and quality, but also provide a certain comfort in performing work activities. Organism and environment form a biological unit. All atmospheric environmental components, physical, chemical and biological, affect the human body. Weather and climate are characterized by meteorological factors.

Weather is characterized by the sum of meteorological inputs that have a short-term character.

Climate is a sum of meteorological inputs with a long-term character.

Weather and its changes characteristic for a certain area constitute a climate or a palate in that particular area.

Weather or climate can directly influence human beings by cold, warmth, rainfall, wind; in case of fieldwork, weather can affect the changes of field production conditions and, by affecting the worker's physical and psychic state, it is likely to influence the work performance.

2. Air temperature – *Temperatura zraka*

Air temperature is closely linked with the human body performance, which decreases with higher temperatures. Physical activity suffers more than the psychic one. The rise in temperature for example by 4°C, from 20°C to 24°C, will cause the fall of physical activity of about 15%. The optimum temperature for medium-hard labor is the temperature range between 15° and 17°C.

A properly dressed and protected person can bear and work in extreme outdoor temperatures from –50°C up to +100°C but its own body only tolerates variations of up to 4°C of the body core temperature without adversely affecting his/her labor and physical efficiency. The lower temperature limit, where an isolated cell is damaged by the creation of water crystals, is –1°C. On the other hand at +45°C the cell proteins coagulate. The cell can bear the temperature above +41°C only for a short time.

Perspiration is a significant element for balancing between the loss and production of warmth. Warmth losses can be influenced by atmospheric humidity.

In a very warm climate, where cooling by evaporation is the main cause of warmth losses because of

high production of perspiration, it can easily lead to restrictions of evaporation caused by inappropriate clothing or high environment humidity.

The parameter that characterizes the isolation capacity of clothing is called thermal isolating clothing resistance whose unit is *clo*. One clo is the isolating resistance of a common man's clothing worn in the countries of middle climate and holds the thermal equilibrium of a person sitting standstill in an environment where the air temperature is 21°C, relative humidity is less than 50% and the velocity is not higher than 360 meters per hour. Under these conditions the thermal production is approximately 210 kJ m^2 per hour and the thermal loss must also equal 210 kJ m^2 per hour so that the person can feel thermal comfort.

For ensuring appropriate clothing isolating features, it is necessary to change clothing for various types of hard physical labor and wear several layers of cloths. Wearing of clothing that can be zipped and unzipped enabling the circulation of air was well acquitted. The air heats itself by the body surface and rises by thermal convection. The ventilation can be reached by opening the top parts of the clothing.

The main problem still remains of the thermal isolation of extremities/limbs especially fingers, which have become the limiting factor for extreme frost tolerance. Feet are the limiting factor for sitting or standing individuals. Wearing shoes with very good isolation and adequate thermal isolation of other body parts enable the individual to bear the foot skin pane at –20°C for approximately 140 minutes and at –40°C for approximately 70 minutes (Matoušek 1987).

3. Rainfall – *Oborina*

Rainfall influences directly a person working in the forest – just by its presence where the performance of certain operations can become more difficult, more exhausting and often impossible. A far greater impact of rainfall can be observed in combination with lower temperatures in winter when the prevailing amount of timber production in the Slovak forestry is carried out. Frozen soil surface or snow cover under which a lot of brushwood is hidden becomes a site of many forest accidents. Due to specific microclimatic forest soil conditions, there is an all-year-round risk of slips and falls. It would be interesting to analyze the impact of other weather factors for example humidity, atmospherics pressure, air circulation, solar radiation and others on the occurrence of work accidents. The effects or concurrence of multiple meteorological factors with one figure are presented by various parameters for example effective temperature, equivalently-effective temperature, cooling-down temperature (refrigeration) (Šamaj et al. 1994).

4. Material and methods – *Materijal i metode*

The aim of the article is to analyze the impact of chosen weather factors on the occurrence of work accidents in a group of forest workers. Due to problem complexity, for the analysis of this issue it was necessary to choose branches[1] typical of the location in lowland and highland areas (in terms of the current climatic classification of the Slovak territory). These criteria were met by Branches Liptovský Hrádok, Námestovo and Kriváň.

Geographical location of the branch Liptovský Hrádok is in the Liptovská fold. The territory is characterized by great relief diversity; it has different altitudes and is therefore climatically diverse with annual average temperatures ranging between 0.2 and 6.3°C. The average annual rainfall is in the interval between 690 and 1810 mm. In this area the snow cover lasts for about 80 to 222 days (Hribik et al. 2008).

The area and location of the branch Námestovo belongs to the geographical region of Orava. This area also has different altitudes, and it is therefore also climatically considerably heterogeneous with annual average temperatures ranging between 0.4 and 4.7°C. The average annual rainfall is in the interval between 720 and 1800 mm. In this area the snow cover lasts for about 100 to 220 days (Hribik et al. 2008).

The branch Kriváň is geographically located in the Pol'ana mountains. Thank to its great orographic diversity this area is also climatically heterogeneous with the annual average temperatures ranging between 3.7 and 6.2°C. The average annual rainfall is in the interval between 720 and 1200 mm. In this area the snow cover lasts for about 80 to 180 days (Hribik et al. 2008).

The primary data for the frequency evaluation of weather-based work accidents were the data on the weather that characterized a certain day or hour when the work accident occurred as well as data on a specific location where the meteorological and pre-

[1] Regional branches of the state-owned enterprise Lesy SR, š.p.

cipitation-gage station was installed. We used the following data:

⇒ air temperature [°C],

⇒ rainfall [mm],

⇒ snow cover [cm],

⇒ soil surface.

The altitude of the occurrence of work accidents was determined by temperature setting. The basic methods used for temperature setting were interpolation or regressive theorem, which enabled us to assign other missing data by using the known temperatures.

The data about rainfall and snow cover were collected from precipitation-gage stations enabling a considerably precise condition setting, because the density of the precipitation-gage stations network is wider than the density of meteorological stations.

The frequency of work accidents can be influenced by the soil surface and by various weather effects. These are listed in the meteorological stations in the form of a code, as for example:

I = dew,

P = coherent snow cover of 1 cm and more,

M = fog, ice fog, ground fog,

Soil surface conditions:

0 = dry soil surface,

1 = wet soil surface,

3 = bare soil surface and frozen.

The data on work accidents were taken from the existing state-owned enterprise Lesy SR work accidents database (Suchomel et al. 2008). The following data were used from the database: the source of work injury, type of injury and injured body part (the criteria were used according to the Ministry of Labor, Social Affairs and Family Regulation No. 500/2006, which specifies the pattern for recording a registered injury). The data were processed with Microsoft Excel. Afterwards different types of charts were created and evaluated.

5. Results – *Rezultati*

The total sum of work injuries listed in the branches Liptovský Hrádok, Námestovo and Kriváň in the research period in the production-transport process was 209. Out of all accidents, 36% occurred during rain, ice rain, or rain shower. In 24 work-accident cases it was snowing or snow occurred and also in 24 cases the snow cover of not less than 1 cm was recorded. In 13% of days (27 cases) when the work accidents occurred, dew was recorded in the research area, which is equal, in case of forest work, to all other above mentioned meteorological factors in maintaining work safety in the sense of work accidents origin group IV – work, or road traffic area as a source of workers' falls, where 29% of injuries were recorded in timber harvesting/logging process in the Slovak forestry sector (Suchomel et al. 2008).

Figure 2 shows the share of injuries by occurrence of specific meteorological factors. In order to sim-

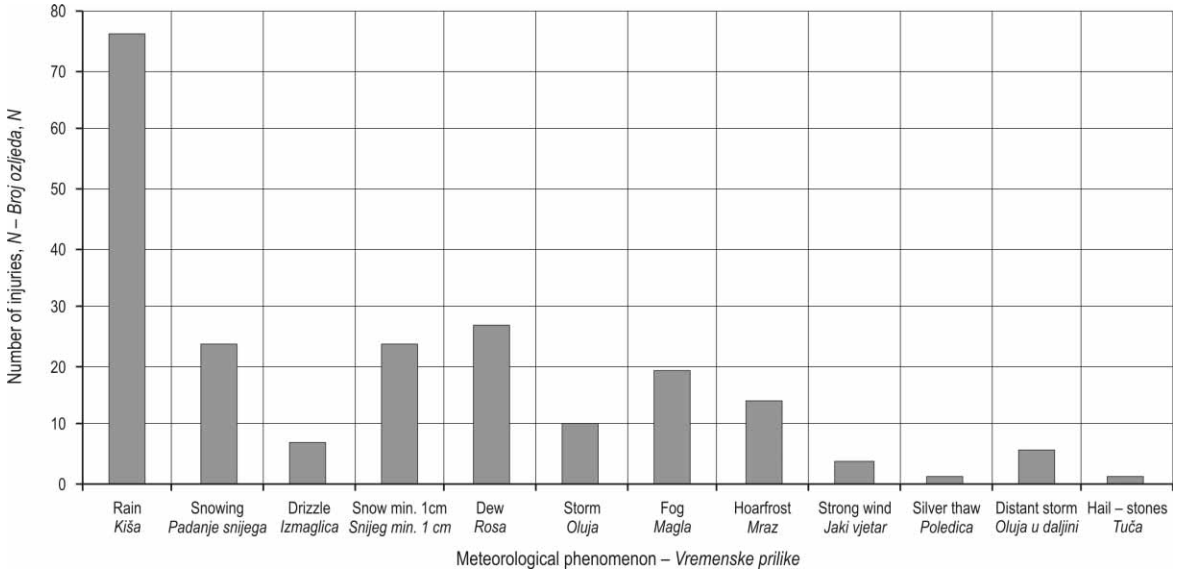

Fig. 1 The most occurring meteorological factors by work injuries

Slika 1. *Najučestaliji meteorološki čimbenici prema ozljedama na radu*

plify the interpretation, injuries with the highest share were aggregated into three groups: wounds, fractures and the third group were wrenches and dislocations mostly concerning lower limbs. Besides the occurring meteorological factors, »dry surface« and »slippery surface« categories were also evaluated by the analysis of accident frequency. In the category »slippery surface«, the following soil surface conditions were considered: wet, soggy and frozen surface. Clearly, the accidents occurred most frequently during rain (72 cases) of which 65% were injuries (surface and open wounds), 21% fractures and 9% wrenches and dislocations. In addition to the graphically illustrated results, injuries were also recorded that required subsequent amputation (for example fingers). These injuries occurred during rain or directly under its influence. With 15 injuries, the work place with slippery surface was recorded as the second most risky work place. The same share of injuries (14 cases) was registered during snow fall, or snow showers and coherent snow cover. Most fractures happened during rain, as already stated above. The total number of 10 fractured body parts was recorded while it was snowing, or with the snow cover and it is interesting that the same number of work injuries with fractures occurred on dry work surface. Besides rain, wrenches and dislocations were most frequently recorded on slippery surface (5 cases) and during dew (4 cases).

Registering work injuries with the ESAW (European statistics on accidents at work) methodology requires the entry of variation category (Fig. 3). The variation describes unusual events as for example partial or whole loss of vehicle control or a fall on something or from something. The most recorded variation was the loss of control, command, whole or partial of the machine, vehicle or manipulating facility, hand gear (tools), object, animal – in 65 cases. We can also consider the negative impact of unfavorable weather conditions on the risk of occurrence of work accidents in these cases but the primary records were not sufficient for a precise analysis. Similarly, only hypothetical statements could be made in the case of variations »uncoordinated workers movements« and »material factor fall, collapse«, where again reliable assessments of variation by unfavorable weather conditions were not possible. In almost 38% of all analyzed work accidents, slip or bad pack – without fall (22 cases) and the worker's slip with subsequent fall (57 cases) as variation or unusual event were recorded. Suchomel et al. 2008 analyzed in detail the frequency of worker's »slips« and »falls« depending on unfavorable weather (snow and/or rain) and the ground slope. For examination and evaluation of this matter the statistical method of contingent table was used. The result of the analysis shows that the statement: Slip and fall accidents at work do not depend on changes of terrain slope and bad weather occurrence, cannot be rejected with a 95% reliability.

By evaluating the sources of work injuries in the relevant data files, it was found out that working or

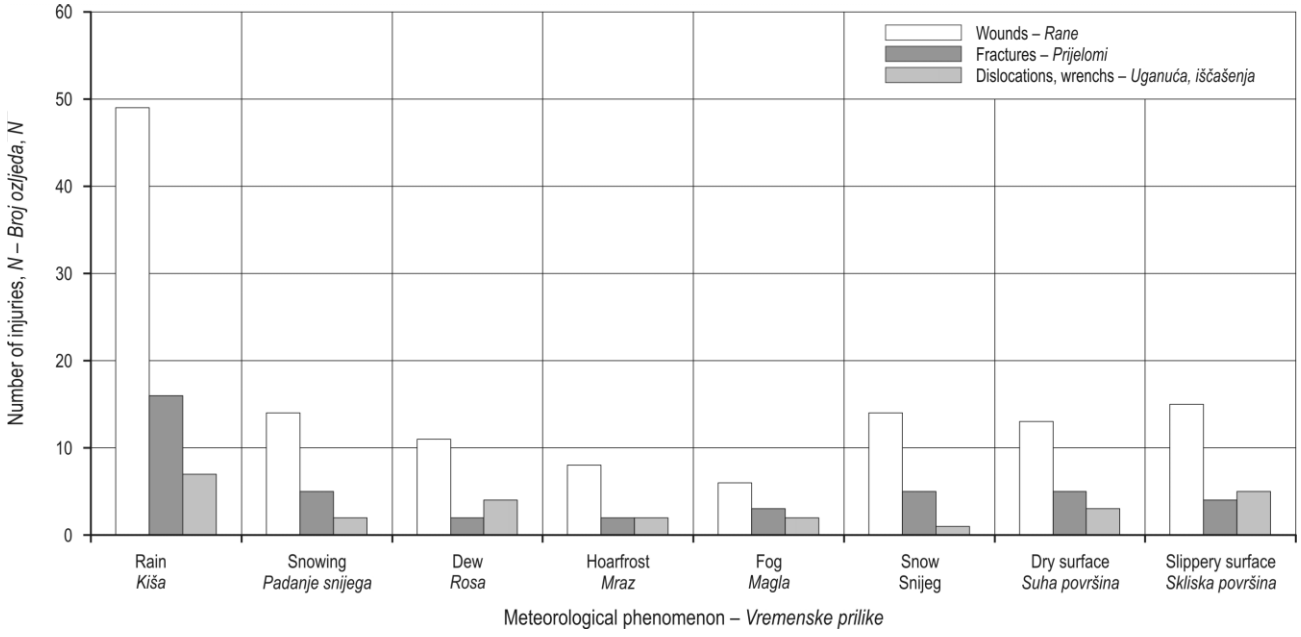

Fig. 2 Injury type and share by occurring meteorological phenomena

Slika 2. *Vrste i broj ozljeda prema vremenskim prilikama*

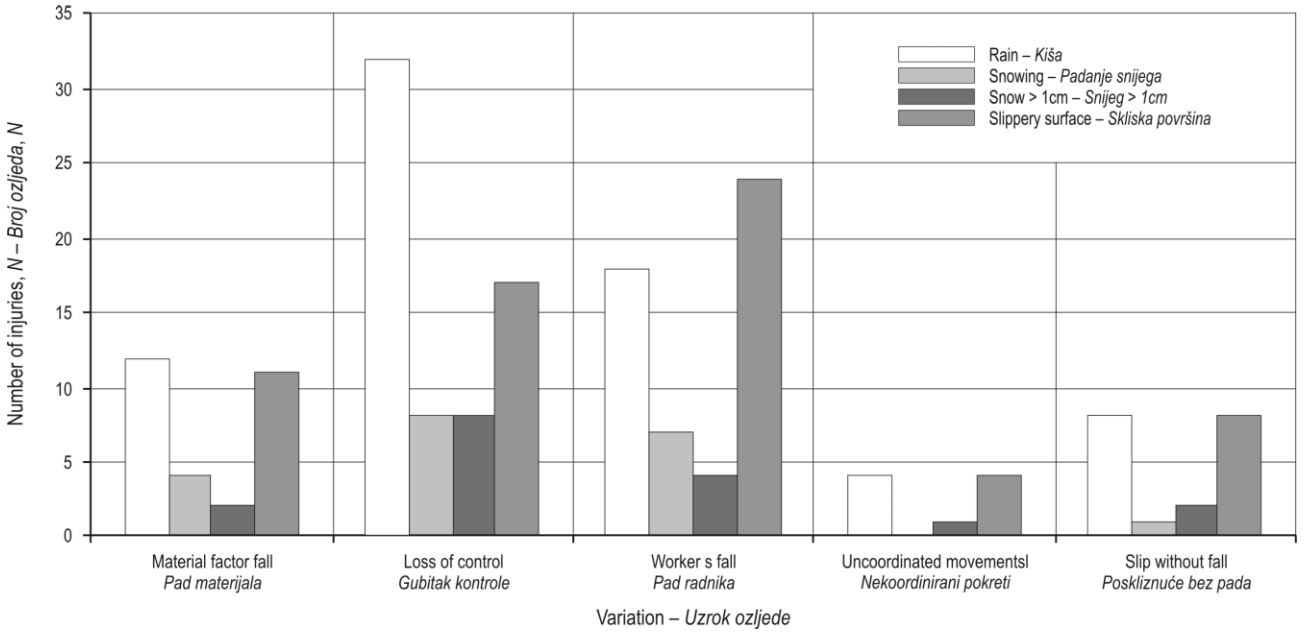

Fig. 3 Variations occurred by meteorological phenomena

Slika 3. *Učestalost uzroka ozljede prema vremenskim prilikama*

road traffic places as the sources of workers' fall were recorded in 53 cases. The highest amount of accidents was recorded on slippery work surface (without rainfall). This phenomenon was also frequent in the source group V – material, burdens, objects and I – means of transport, where workers slips often occurred in entering the vehicle, or in leaving it. Approximately 10% of all accidents happened when snow cover higher than 1 cm was present. As stated above, clearly the most frequently registered accidents occurred during rain and the most frequent accident source during this weather was group III – machines, where a transportable chain saw is also included, as well as group II – raisers and transport-

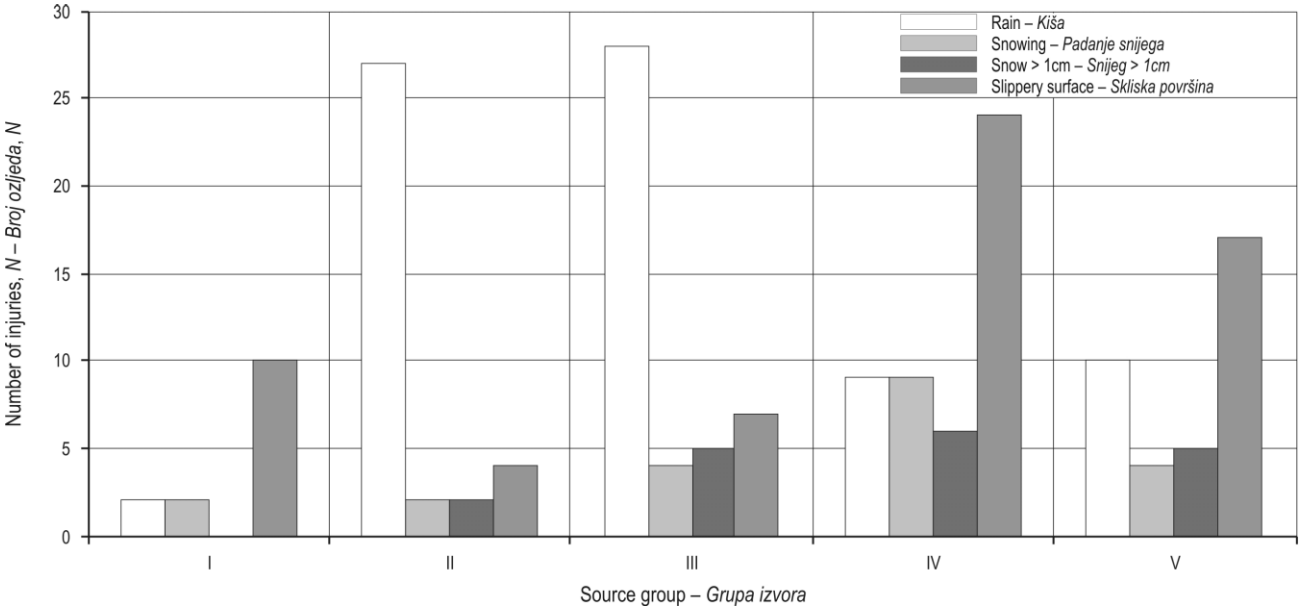

Fig. 4 Sources of injuries occurred by meteorological phenomena

Slika 4. *Učestalost izvora ozljeda prema vremenskim prilikama*

ers, raising and transporting tools. During rain, any activity in the forest is dangerous, not to speak about performing difficult and risky work activities such as logging.

5. Conclusion – *Zaključak*

It can be concluded that out of 209 work accidents in 190 cases the occurrence of some metrological phenomena was recorded. The most frequent phenomenon was rain (36%), in 13 percent of days (27 cases), where an accident occurred, dew was recorded in that location, in 24 cases it was snowing and similarly in 24 cases of work accidents, snow cover higher than 1 cm was recorded. Besides rain, the most frequent injuries, wrenches and dislocations were recorded on slippery surface, and fractures occurred mostly as a result of snow fall or snow cover. Slips and falls were mostly recorded during rain and also on slippery surface without the occurrence of any meteorological phenomena. The share of slippery surface in the cases of work accidents also corresponds to 25% of source accident group IV – work places.

The occurrence of unfavorable weather cannot always be absolutely predicted. The elimination of work accident risks in these conditions is possible, especially by providing the proper protection at work, enhancing safety measures and especially by complying with the prescribed technological procedures.

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Sažetak

Utjecaj vremenskih prilika na učestalost ozljeđivanja u postupcima pridobivanja drva

Vrijeme i klima značajno utječu na učinkovitost i kvalitetu rada, ali i na sigurnost pri obavljanju šumskih radova. Sve atmosferske sastavnice okoliša, fizičke, kemijske i biološke, djeluju na ljudski organizam koji zajedno s okolišem tvori jednu zajedničku biološku cjelinu. Klima i vrijeme pritom su određeni meteorološkim čimbenicima, vrijeme kao zbroj meteoroloških čimbenika koji imaju kratkoročan karakter, a klima kao zbroj meteoroloških čimbenika s dugoročnim djelovanjem. Vrijeme i vremenske promjene karakteristične za određeno područje tvore klimu toga područja. Vrijeme ili klima izravno utječu na čovjeka preko hladnoće, topline, oborine, vjetra i dr. Pri radu na otvorenom vrijeme može djelovati na promjenu uvjeta rada i na obavljanje posla utjecajem na psihičko i fizičko stanje radnika. Temperatura je zraka snažno povezana s izvedbom ljudskoga organizma koja opada s višim temperaturama. Psihička aktivnost pritom trpi više od fizičke. Porast temperature za npr. 4 °C, s 20 °C na 24 °C, uzrokovat će smanjenje psihičke aktivnosti za približno 15 %. Optimalna temperatura za srednje težak rad je temperatura između 15 i 17 °C. Oborina izravno utječe na radnika pri radu u šumi. Samom pojavom oborine obavljanje šumskih radova postaje teže, iscrpljujuće i često nemoguće. Mnogo veći utjecaj oborina može imati zajedno s niskom temperaturom i pojavom snijega zimi. Smrznuta površina tla i snježni pokrivač skrivaju mnoge opasnosti i postaju mjesta brojnih nesreća u šumarstvu.

Cilj je ovoga rada bio da se istraži utjecaj odabranih meteoroloških prilika na učestalost pojavljivanja ozljeda pri šumskim radovima u slovačkom šumarstvu. U članku se također analiziraju brojnost i vrste ozljeda te uzroci i

izvori ozljeda na radu. Istraživanja su provedena u tri regionalne podružnice državnoga šumarskoga poduzeća Lesy SR. Podružnice Liptovský Hrádok, Námestovo i Kriváň odabrane su, s obzirom na klimatsku klasifikaciju Slovačke, kao predstavnici tipičnih lokacija nizinskih i gorskih područja. Podaci o ozljedama na radu preuzeti su iz službenih evidencija državnoga šumarskoga poduzeća. Kao osnovni ulazi za procjenu učestalosti ozljeda uzrokovanih vremenskim prilikama uzeti su podaci o vremenu tijekom određenoga dana ili sata u kojem se dogodila nesreća i podaci o točnoj lokaciji nesreće odnosno mjerenja najbližih meteoroloških postaja.

Ukupno je na pridobivanju drva u promatranom razdoblju zabilježeno 209 ozljeda na radu. Od ukupnoga broja nesreća 36 % ih se dogodilo za vrijeme kiše, tuče ili pljuskova. U 24 slučaja je sniježilo i isto tako u 24 slučaja ozljede su se dogodile pri snježnom pokrivaču većem od 1 cm. U danima kada su se dogodile ozljede na radu u 13 % njih (27 nesreća) na radilištima je zabilježena rosa. Najviše se nesreća (72 ozljede) dogodilo prilikom padanja kiše, a od toga je 65 % površinskih i otvorenih rana, 21 % prijeloma i 9 % uganuća i iščašenja. Oko 10 prijeloma zabilježeno je za padanja snijega ili pri snijegom pokrivenom tlu. Jednak broj ozljeda s prijelomima se dogodio i na suhoj radnoj površini. Osim na kiši uganuća i iščašenja najčešće su zabilježena na skliskoj površini (5 slučajeva) i pri rosi (4 slučaja). S obzirom na mjesto nastanka ozljeda radni je prostor kao izvor padova pri radu na pridobivanju drva zabilježen u 29 % nesreća. Skliska površina (bez kiše) s 15 ozljeda drugi je najznačajniji izvor nesreća. Kao najčešći uzrok ozljeda u 65 slučajeva naveden je gubitak kontrole i moći upravljanja nad radnim sredstvom – strojem, vozilom, ručnim alatom i predmetom rada. Gotovo u 38 % svih analiziranih nesreća posklizнuće bez pada (22 slučaja) i posklizнuće s padom radnika (57 slučajeva) zabilježeni su kao uzrok ozljeda.

Pojava nepovoljnih vremenskih prilika ne može se uvijek točno predvidjeti. Otklanjanje rizika od nesreća u takvim uvjetima ipak je moguće, i to odgovarajućom zaštitnom opremom, povećanom pažnjom pri radu i osobito primjenom pravilnih tehnoloških postupaka.

Ključne riječi: šumarstvo, šumski rad, sigurnost pri radu, ozljede, vrijeme, meteorološke prilike

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