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# Using The Potential Of The Employees' Expertise And Awareness Of Occupational Hazards In The Mining Industry

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**Abstract.** The paper highlights the results of a study that examined the employees' expertise and awareness of occupational hazards in their work environment. The research involved a survey conducted in the form of a short questionnaire among employees responsible for loading and hauling of excavated material in an opencast mine. Among 23 major hazards that were thus identified, there were global hazards (affecting the entire mining process) as well as local, task-specific hazards. Depending on the number of responses, 10 local and 3 global hazards were identified in the analyzed area, involving noise, stress and dust. Active participation of the crew in the risk identification process helped in the assessment of their criticality levels, according to employees carrying out various task, highlighting the benefits of such approach for effective work safety management in a mining company. The conducted research demonstrated yet another goal to be achieved - i.e. the comparison of criticality levels of hazards as identified by employees and those reported in occupational risk assessment reports in the mine.

**Key words:** hazard identification, occupational risk assessment, survey, surface mining

## 1. Introduction

The mining sector still ranks among the most hazardous industries, due to unfavourable operating conditions and in the case of miners, the working conditions are variable, both in terms of specific tasks or operations to be performed and complexity of the mining production process and diversity of operating conditions. In many cases miners are faced with high job demands (excessive workloads), negatively impacting on their health condition or life-threatening. Occupational hazard is defined as the probability of undesirable events and impacts (consequences) associated with the specified operation or task carried out, taking into account the criticality of these events. It is associated with the probability of a job-related undesirable event resulting in material losses and producing negative impacts on humans (their health and safety at work). According to the current legislation, it is the employer's responsibility to conduct the occupational risk assessment at workplace and to provide the employees with relevant information on hazards and risks within the workplace [13].

The first stage of the occupational risk assessment procedure involves the collecting of necessary data for identification of all potential hazards to be encountered at work. There are two major steps yielding the data for further analysis and having a direct influence on the assessment results. The main aim of this study is to highlight a new source of information about the potential hazards and risks at work, namely the employees' expertise and experience of surface mining and their perception of the criticality of occupational hazards and risks within the worksite.

## 2. Risk assessment procedure in Polish companies - general outline

Generally, the aim of the occupational risk assessment is to identify all hazards and risks within the workplace and to establish the associated risk level. Every specific task or operation, regardless of its type and the place where it is carried out, involves an exposure to risk. It is the employer's responsibility to provide employees with information on occupational hazards and risks within the workplace and to put in place the control measures to eliminate or control their negative impacts. The employer's responsibilities in this respect are set forth in the Labour Code. Art 226 of the Law of 26th June 1974 "Labour Code', imposes a duty on the employer 1) to evaluate and document the risks associated with the performed tasks and operations, and to put in place the control measures aimed to minimise the risk exposure; 2) to provide employees with information on hazards and risks affecting specific tasks and operations carried out by them and to instruct them in the use of protective measures [13].

The definition of the occupational risk is provided in the Regulation by the Minister of Labour and Social Policy on General Provisions on Occupational Safety and Health of 26th September 1997 [16]. Occupational risk is defined as the probability of an undesirable event related to the performed task or

operation, resulting in material loss and, specifically, having negative impact on humans due to occupational hazards present in the work environment or related to the working method. In accordance with paragraph 39 of the said Regulation, the employer is obligated to evaluate and document the hazards and risks affecting specific tasks and operations to be carried out and to put in place necessary preventive measures aimed to minimise the risk exposure. The principle whereby the occupational risk exposure should be minimised can be summarised in terms of a safety triad model, incorporating three basic components: avoiding hazards, adopting solutions on the level of organisation and adoption of group protection measures, providing information about residual risks and application of individual protection equipment [14]. These principles stem directly from the above-mentioned Regulation having relevance to general occupational health and safety requirements, specifically from Art 39 wherein the employer's responsibilities in the context of occupation risk management are listed in this order.

In the final stage of the risk evaluation procedure, the risk levels obtained from analyses are compared with the risk tolerability levels. The results of occupational risk evaluation are used to facilitate the decision-making in matters relating to risk tolerance or management [15].

Prior to the occupation risk evaluation it has to be established whether it should concern a specific worksite, a process, or an object as a whole or their sections or parts, which might require a separate analysis. In the first stage of the risk evaluation procedure the worksite (an object or process) are described, its extent defined and all relevant data are compiled.

Identification of hazards and risks within the workplace, which is a major step in the occupational risk evaluation, requires a systematic approach to detect the largest possible numbers of potential hazards and unfavorable, hazardous conditions that may lead to an exposure to risk. Several methods have been developed to facilitate full and exhaustive identification of potential hazards (HAZOP, WHAT-IF, CHECK LIST) which provide a detailed procedure to be adopted for hazard detection.

The final stage consists in the risk evaluation whereby specific hazards are aligned with the associated risk levels, in accordance with the adopted measure. Each method provides the principles used to establish the risk level depending on the probability of the hazard occurrence and severity of its impacts [19]. All these methods differ in the level of specificity and detail, and the relevant regulations do not stipulate the use of any particular risk assessment method. Widely used methods include that specified in the technical standard PN-N-18002, alongside the Risk Score, Five Steps or the PHA (Preliminary Hazard Analysis) approach. Amongst the most popular methods is that provided in the standard PN-N-18002 and the Risk Score approach. Risk assessment in accordance with these methods involves the examination of each potential hazard which in turn may produce certain impacts [20].

Occupational risk assessment ought to be conducted at regular intervals and whenever the information and data on which the procedure relies have become outdated; moreover, the risk assessment is requisite when:

- a new job position is being designed;
- job positions are to be changed or modified;
- after a change of conditions and requirements relating to the job positions being evaluated
- after a change of the adopted protective measures

## 3. Identification of work-related hazards

Identification of hazards involves a reconnaissance to find out whether a given hazard is present at workplace and to determine its characteristic: 'Hazards include all aspects that have negative impact on employees' health or put their health in jeopardy - machinery and equipment, working methods and organisation, chemical substances, electricity, as well as psychosocial hazards and factors associated with strenuous effort while lifting or moving heavy objects, static or monotype tasks" [5]. The awareness and knowledge of the hazards present and their extent is requisite for the occupational risk assessment, incident rate analyses, employee training or optimisation of tasks and operations [3, 8, 10, 12].

### 3.1 Sources of information about hazards and risk within the workplace

Main sources of information on hazards and risks in the given work environment include:

- Technical specifications of objects (systems) or processes
- Procedures and instruction manuals

- Statistics of the rate of accidents and incidents at work, job-related illnesses and events that may potentially result in an accident
- Observations of tasks and operations carried by the person within the given workplace
- Interviews with employees
- Measurements of hazardous factors within the workplace
- Observation of external factors which may affect the employee's behaviour at workplace
- Analysis of psychosocial or physical hazards and factors giving rise to stress
- Analysis of organisational activities aimed to ensure the adequate working conditions [19].

Data collection is based on a variety of methods and techniques, including the examination of company documents, control reports and questionnaires [11, 17], collective observations [7], case studies [9], surveys (including questionnaires, discussions, brainstorming, expert opinions) [4].

Studies investigating the safety risks perception and handling by employees (including the mining crews) have revealed that for most employees identification of hazards within the workplace is problematic, hence the difficulty with the correct assessment of associated risks. Of particular importance, on the other hand, is professional experience of employees (their knowledge of tasks and operations to be performed), supervision, participation in employee training – all these enhance the ability to predict the hazard occurrence and calculate the risk [1, 2, 4, 6, 9].

### 3.2 Methodology

The study concerned an surface mine and the related mining operations, loading and hauling of the excavated material, as well as processing operations. The main focus was on two activities: loading and hauling of the excavated material and on job positions directly related to these activities, supervisory positions and those involving the control of machinery and equipment (Fig 1).

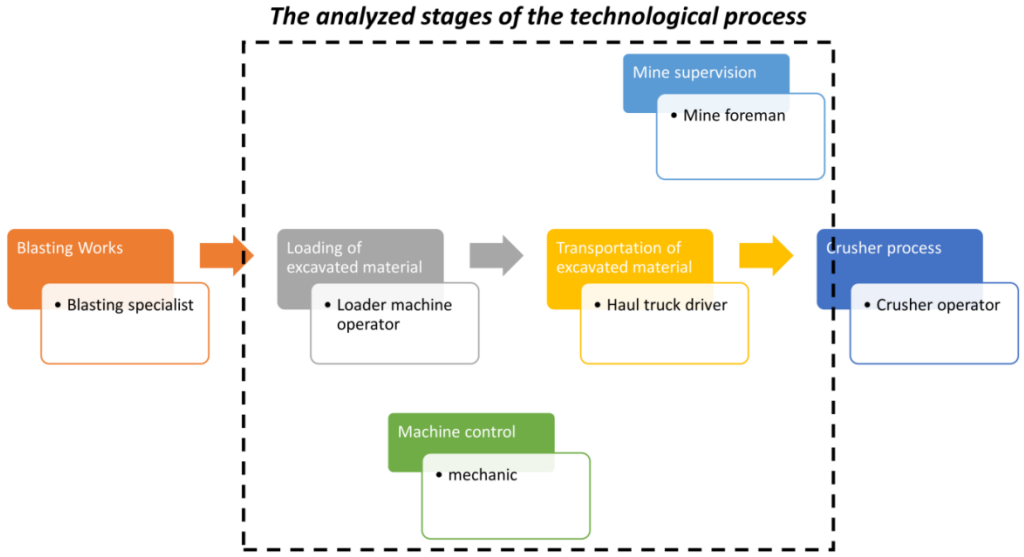
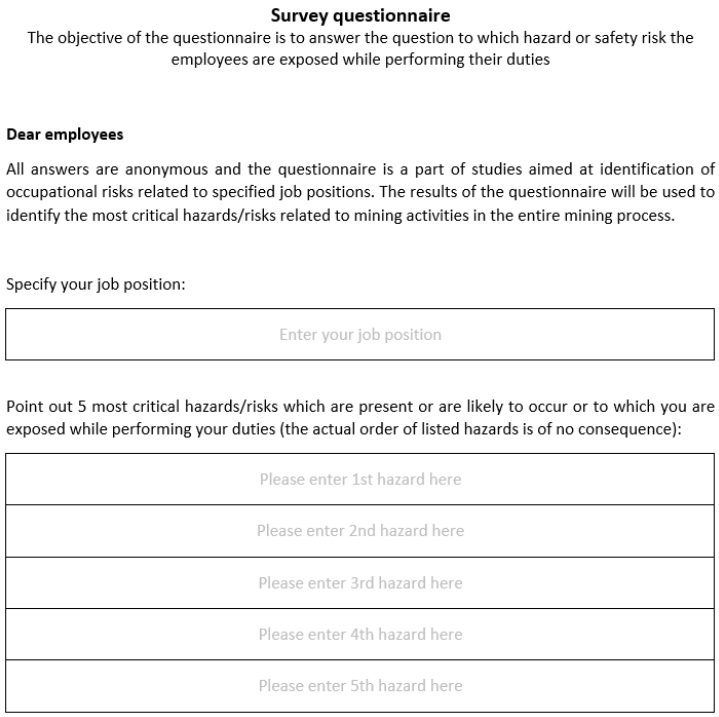



**Fig. 1.** Activities and operations in an surface mine, with the specified job positions

Identification of hazards and risks and specification of related jobs and job positions was based on the employees' questionnaire whereby the respondents, being crew members occupying the given positions, were asked to point out 5 most critical safety hazards or factors that were present or were likely to emerge in the work environment as well as those which affected the specific tasks and operations carried out by those persons (Fig 2).



**Survey questionnaire**

The objective of the questionnaire is to answer the question to which hazard or safety risk the employees are exposed while performing their duties

**Dear employees**

All answers are anonymous and the questionnaire is a part of studies aimed at identification of occupational risks related to specified job positions. The results of the questionnaire will be used to identify the most critical hazards/risks related to mining activities in the entire mining process.

Specify your job position:

Enter your job position

Point out 5 most critical hazards/risks which are present or are likely to occur or to which you are exposed while performing your duties (the actual order of listed hazards is of no consequence):

Please enter 1st hazard here

Please enter 2nd hazard here

Please enter 3rd hazard here

Please enter 4th hazard here

Please enter 5th hazard here

**Fig. 2.** Questionnaire model - List of 5 most critical hazards [18]

## 4. Criticality of hazards in the work environment on the basis of the questionnaire

The survey conducted at the mining company had 15 respondents occupying 4 different positions (Table 1):

- Hauling truck drivers – 6 employees
- Loader machine operators – 3 employees
- Mechanics – 4 employees
- Mine foremen (deputies) – 2 employees

This number of respondents is closely related with the number of crew members in an surface mine. The largest group were dump truck drivers, who were able to identify the largest number and a wide range of hazards. Next in line came the mechanics (13 hazards) and loader machine operators (13 hazards). The smallest group were the mine foremen who identified 5 identical hazards (Table 1).

**Table 1.** Survey results

| Job/position | Mechanic | Haul truck driver | Mine foreman | Loader machine operator |
|---|---|---|---|---|
| The number of employees | 4 | 6 | 2 | 3 |
| The number of identified hazards | 13 | 18 | 5 | 13 |

Altogether, 15 workers were able to identify 23 diverse hazards (Fig 3). Amongst the frequently listed hazards and factors were:

- Dust (10)
- Noise (8)
- High fall (8)
- Stress (7)

- Mechanical vibration (6)

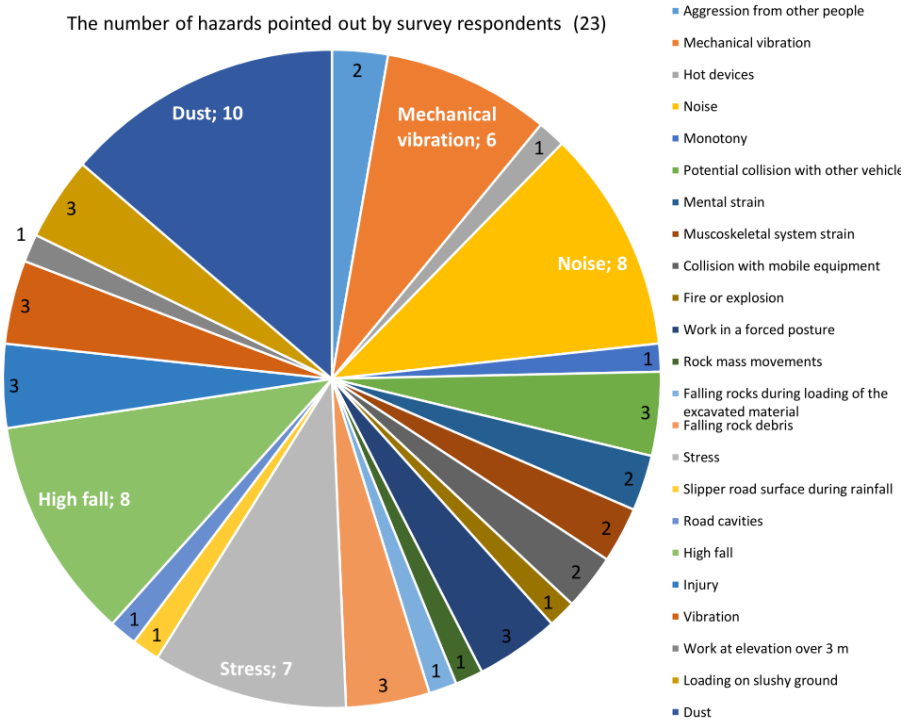



**Fig. 3.** The number of hazards pointed out by survey respondents

The actual distribution of hazards and factors pointed out by those taking part in the survey is shown in Fig 4, highlighting those hazards and factors that are perceived as most critical in their jobs.

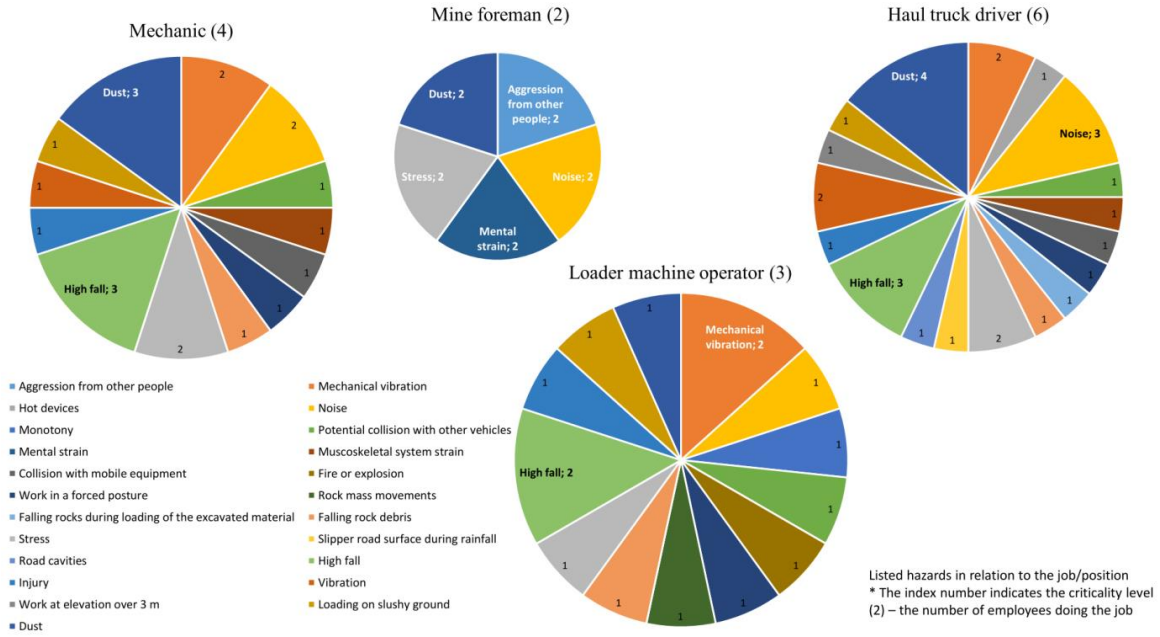



**Fig. 4.** Distribution of hazards and factors associated with given jobs

In the case of the most numerous group: dump truck drivers, amongst the most critical hazards listed were the dust- pointed out by 4 employees (66% employees doing the given job), high fall and noise- each listed by 3 employees (50%). The next in line came the mechanics, who pointed out to dust and high falls as the most critical hazards- each listed by 3 employees (75%). Loader machine operators pointed out to high falls and mechanical vibration as the most critical hazards- each listed by 2 employees (66%). The only group of employees whose lists of hazards were found to be identical were mine foremen (deputies), who pointed out to dust, stress, noise, mental strain and aggression from other people.

Certain hazards and factors were pointed out only by those doing the specified job (occupying one position), which indicates that these hazards and factors are local, task-related. On the other hand, there are some hazards and factors which affect 2,3 or even 4 jobs. Those hazards and factors that are identified on all analysed worksites can be regarded as inherent in the mining process in its entirety, and referred to as 'global' (Fig 5).

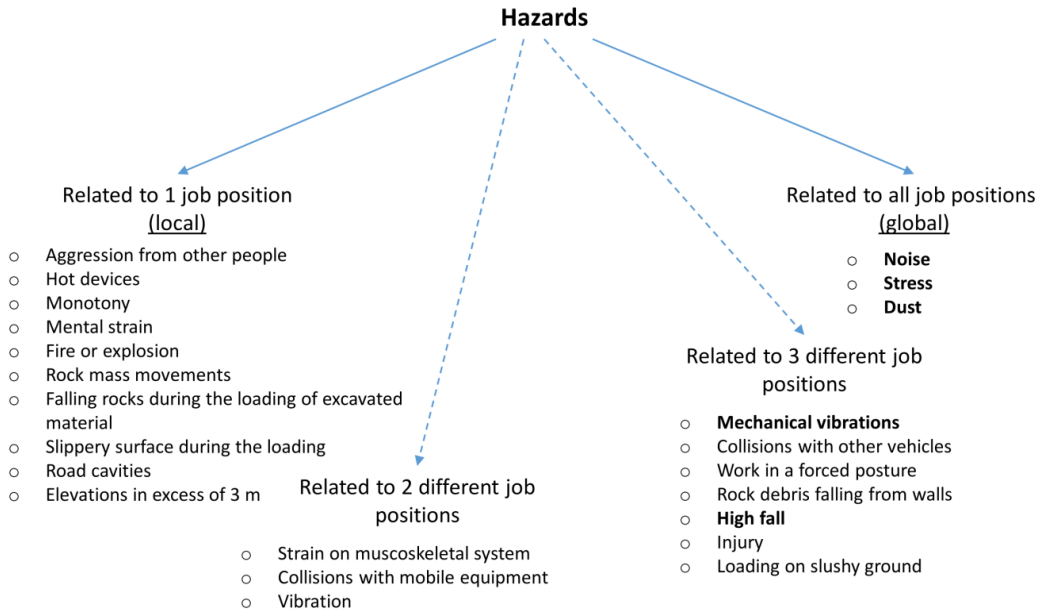



**Fig. 5.** Impacts of individual hazards at various stages of the surface mining process

Global hazards related to each task and job position include noise, stress and dust. Moreover., these particular hazards were most frequently pointed out by the respondents in the survey. The other group includes hazards and factors emerging at some stages of the surface mining process (related to 3 out 4 analysed job positions), such as mechanical vibrations, high fall, work in a forced posture, potential collisions with other vehicles, falling rock debris and loading of the excavated material on slushy grounds. The first two hazards from the second group (indicated in bold in Fig 5) are among those most frequently pointed out by all survey respondents.

Another important aspect is the specification of hazards pointed out by employees in relation to their tasks /job positions. Thus, the summary of results provides a compilation of hazard criticality levels as perceived by employees and the scale of their impacts in relation to the number of analysed job positions (Table 2). Thus the local hazards are highlighted – for example, dump truck drivers pointed out to 5 hazards related to their job. Similarly, loader machine operators pointed out to 3 such hazards whilst mine foremen identified 2 hazards (as well as 3 global hazards, related to the entire mining process). Mechanics, as survey respondents, did not point out any hazards affecting only the tasks and operations carried out by them (Fig. 6).

| | | Hazard level of impact | | | | Job position | | | |
|---|---|---|---|---|---|---|---|---|---|
| Type of hazard | Total times indicated | Related to 1 job position (local) | Related to 2 different job positions | Related to 3 different job positions | Related to all job positions (global) | Mechanic | Haul truck driver | Mine foreman | Loading machines operator |
| Dust | 10 | NO | NO | NO | YES | YES | YES | YES | YES |
| Noise | 8 | NO | NO | NO | YES | YES | YES | YES | YES |
| High fall | 8 | NO | NO | YES | NO | YES | YES | NO | YES |
| Stress | 7 | NO | NO | NO | YES | YES | YES | YES | YES |
| Mechanical vibrations | 6 | NO | NO | YES | NO | YES | YES | NO | YES |
| Possibility of collision with other vehicles | 3 | NO | NO | YES | NO | YES | YES | NO | YES |
| Work in a forced posture | 3 | NO | NO | YES | NO | YES | YES | NO | YES |
| Rock debris falling from walls | 3 | NO | NO | YES | NO | YES | YES | NO | YES |
| Injuries | 3 | NO | NO | YES | NO | YES | YES | NO | YES |
| Vibrations | 3 | NO | YES | NO | NO | YES | YES | NO | NO |
| Loading on slushy ground | 3 | NO | NO | YES | NO | YES | YES | NO | YES |
| Aggression from other people | 2 | YES | NO | NO | NO | NO | NO | YES | NO |
| Mental strain | 2 | YES | NO | NO | NO | NO | NO | YES | NO |
| Strain on the musculoskeletal system | 2 | NO | YES | NO | NO | YES | YES | NO | NO |
| Collision with mobile equipment | 2 | NO | YES | NO | NO | YES | YES | NO | NO |
| Hot devices | 1 | YES | NO | NO | NO | NO | YES | NO | NO |
| Monotony | 1 | YES | NO | NO | NO | NO | NO | NO | YES |
| Conflagration or explosion | 1 | YES | NO | NO | NO | NO | NO | NO | YES |
| Rock mass movements | 1 | YES | NO | NO | NO | NO | NO | NO | YES |
| Falling rocks during loading of the excavated material | 1 | YES | NO | NO | NO | NO | YES | NO | NO |
| Slippery road surface during rainfall | 1 | YES | NO | NO | NO | NO | YES | NO | NO |
| Road cavities | 1 | YES | NO | NO | NO | NO | YES | NO | NO |
| Height over 3m | 1 | YES | NO | NO | NO | NO | YES | NO | NO |

**Fig 6.** Summary of a research study on identification of hazards

## 5. Conclusions

The study summarises the result of a research study in which the employees were invited to contribute to the hazard identification being a part of the occupational risk evaluation procedure in an surface mine. Employees occupying various positions in a surface mine were thus encouraged to actively participate in a survey. Identification of hazards in the occupational risk evaluation by the mining crew is a dynamic process because the working conditions tend to change, new hazards may emerge with the advancement of mining operations (including natural hazards) and, last but not least, because of complexity of

operations involved in the surface mining process in the natural surroundings. The respondents – employees in the mine duly identified 23 occupational hazards and factors, pointing out those which they perceived as most critical within their worksite. The survey results suggest that the analysed mining process is affected by 10 local and 3 global hazards, depending on the actual listing by crew members responsible for loading and hauling of excavated material. Additionally, the survey revealed that:

- Those employed as mechanics pointed out mostly to hazards affecting at least 2 operations (job positions);

- Mine foremen pointed out 2 hazards affecting their job positions only and three global hazards, i.e. those related to the entire mining process;

- Only those responsible for hauling of the excavated material pointed out to hazards or factors affecting each level of operations. They were able to identify hazards related to one, two, three or even four operations and job positions.

The approach outlined in the study whereby the employees' expertise and experience is recalled in the risk identification is a move towards ensuring the crew's active participation in the occupation risk assessment, provides an additional source of information on hazards and risks within the workplace, highlights a large number of potential hazards to be analysed in the occupational risk assessment procedure. Thus the risk assessment results become more reliable, which is of primary importance in the context of planning further actions as a part of the occupational risk management in the mining industry.

The study highlights the need and directions for further research to verify whether the hazards and factors pointed out by employees can also be found in the occupational risk evaluation reports and to find out how the respective criticality levels should compare.

Similar surveys are planned to be conducted in other surface mines to establish the level of employees' awareness of hazards and risks within the workplace.

## 6. Acknowledgements

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