THE NOISE AT THE OPEN PIT MINE POTOCARI IN TUZLA CANTON

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Abstract: *The impact of production processes to working conditions in open-pit mines, primarily in terms of noise on the example of the open pit "Potocari" at mine "Djurdjevik" was studied in this article. Significant wide interval in which the measured noise of varying intensity, are observed on the basis of analysis of the measured levels of noise-intensity transmitted in the working area of the open pit by individual production processes. Based on the "in-situ" measured values are proposed methods and preventative measures to protect to avoid or reduce to a minimum adverse effect of noise on workers in the open pit mine. Based on the results of the measurements can be performed by a general conclusion that occasionally occurs exceeding the allowed level of noise, but the noise a short duration, so it leaves no adverse consequences. In the immediate vicinity of mobile machines there are not employees (other than direct operator) in which the noise of them could leave the consequences due to prolonged exposure. In places where the noise level exceeds the permitted intensity - the "threshold", was applied adequate protective equipment.*

Keywords*: noise, pit mine, shovel, truck, digging, loading, transport, environmental.*

1. INTRODUCTION

The basic characteristics of surface exploitation are outdoor work, which is directly exposed to atmospheric conditions, with the engagement of robust mechanization and other equipment with relatively few crews (drilling rigs, excavators, crushing plants, transport systems, landfills, etc.). Workers in mining (here primarily refer to workers in production, operators, maintenance workers, etc.) perform work in specific conditions, where the adjustment of working environment and means of work is limited to the worker. By increasing the depth of the surface mines, depending on the applied technology and the exploitation system, the projected construction and the configuration of the mine, the geographical location of the deposit and other conditions, it is necessary to increase the

productivity of equipment used in the processes of exploitation of mineral resources, but there are also serious problems with air pollution in the area of the crater of the dig and its immediate surroundings (Aloui, et al. 2016: 1, Bafeni&Kosasan 2009: 2, Brigić et al. 2013: 3, Pleban et al. 2013: 8).

In this paper, the influence of production processes on working conditions in surface mines on the example of the surface mine "Potocari" Djurdjevik was investigated. By measuring the noise level at characteristic sites in the surface mine, data for analysing the impact of production processes on the pollution of the surface of the surface from the aspect of noise were collected. In addition to measuring the noise level at each measuring point, the temperature and humidity of the air in the open pit were recorded.

2. METHODOLOGY AND MATERIALS

In technological processes of coal production and processing, inevitably there is noise, which causes a negative impact on the quality of the work and environment. One way to combat this problem is zoning - noise mapping. The methodology of noise mapping within the surface coal mine is described in this paper. On the example of the open pit mine Potocari, a model for noise mapping was developed in the function of defining measures for remedying the negative impact of noise in the immediate vicinity of the surface mine (Aloui et al., 2016: 1,Brigic et al. 2013: 3, Pleban et al. 2013: 8, Stanci et al. 2014: 10, Hegley 2011: 6, Department of Economic DJTR 2015: 11).

The following must be done in the methodological approach:

- analysis of available literature and references related to the subject matter,
- analysis and synthesis of previous research in the subject area,
- In-situ measurements of working conditions in the surface mine (noise, as well as the temperature and humidity of the air at the measurement site),
- analysis of the impact of production processes on working conditions in the surface mine, especially from the aspect of noise.

Noise, in the physiological sense, defines every unwanted sound in the environment in which people live and work, and that causes an uncomfortable feeling or may adversely affect health. Noise responses are individual, and dependent on subjective noise parameters (noise, volume

and noise levels). Depending on the level and frequency of the noise, and the noise exposure period, they can be from mild and transient to permanent damage (Bugarski-Golubović 2010: 4, Simonovic et al. 1982: 9, National law act of FB&H 2012: 14, National law act of Serbia 2011: 12).

Table 1 Distribution of noise types according to different criteria

Source of noise	According to the frequency domain	According to the share of noise sources
According to the time flow	Broadband	Total
According to the frequency spectrum	Baseband	Specific
According to the share of noise sources	Total	Residual
According to the source of impulse noise		Initial

2.1 Basic noise parameters

In order to assess the unfavourable ergonomic conditions in the working and living environment due to noise, and to take appropriate protection measures, the basic noise characteristics as well as the noise management system are determined. The methods of managing the noise of the work space and the environment represent an integral model of solving the problems of excessive levels of noise that the employees and the population are exposed daily (Bugarski-Golubovic 2010: 4, Pleban et al. 2013: 8, National law act of FB&H 2012: 14, National law act of Serbia 2011: 12).

A comprehensive noise management system presents:

- Measurement - use of acoustic measurements in order to accurately characterize the observed sources of noise,
- Monitoring - the use of non-controlled acoustic measurement methods in order to accurately monitor the time variation of the noise level of the observed sources,
- Management - the use and management of all protection systems in a single, live interactive system,
- Method of interviewing people in the work and environment,
- Mathematical modelling.

Noise sources must not emit noise that exceeds normatively determined levels in the surrounding area. The highest permissible levels of noise are defined by the "Noise Protection Act" (Table 2).

Table 2 Permissible noise levels

Area	Purpose of the area	Highest allowed levels (dB)		
		equivalent levels		peak levels
		day	night	
I	hospital-health resort	45	40	60
II	tourist-recreational-recovery	50	40	65
III	housing, educational and health institutions, public green and recreational areas	55	45	70
IV	commercial, business, housing and housing along transport corridors, warehouses without heavy transport	60	50	75
V	business, administrative, trade craft, service	65	60	80
VI	industrial, warehouse, service and traffic area without housing	70	70	85

2.2 The subject of research for applied methodology

The brown coal mine "Djurdjevik" occupies an area of 1050.28 ha and extends in the Tuzla Canton area. This mining complex dates from 1936. The brown coal mine "Potocari" mine "Djurdjevik" has a carbon layer at an angle of 28° -33° and belongs to a slice bearing on which a transversal one-quarter system of exploitation is applied (Figure 1). The exploitation of coal is carried out at a depth of more than 150 m. The projected height of the bench is 12 m (Technical documentation of Mine Djurdjevik: 13).

Figure 1 Satellite footage of the open pit mine "Potocari"

On the open pit mine "Potocari" for the production of coal, the classic cyclic loading and transport complex excavator-trucks is applied, and on the acquisition of the detection, the combined transport truck-crusher plant-strip conveyor-stacker is applied (Technical documentation of Mine Djurdjevik:13). In such conditions, a constant noise emission of a different level occurs. In addition to noise emitted from truck units, significant noise emissions are also produced by excavator units, as well as auxiliary machines in operation. For this research, characteristic points were selected for measuring the noise level, as well as the temperature and humidity of the air at the moment of noise level measurement.

2.3 Measurement of data

The sources of noise on a surface mine can be considered according to production processes: drilling, mining, loading and transport, trucks, crushing units in combined transport, belt conveyors, and trappers. In addition, significant source of noise on the surface mine is machines and devices used on auxiliary production processes such as bulldozers and graders on the construction and maintenance of roads at pit mine, backhoe loaders, pumps, compressors, etc.

Measurements were performed on the open pit mine "Potocari"-Djurdjevik with instruments Digital multimeter with environment measurement PCE-EM886 presented on figure 2.

Figure 2 Digital multimeter with environment measurement PCE-EM886

3. RESULTS OF MEASUREMENT AND CALCULATIONS

3.1 Results of measurement, temperature and humidity during operation of the excavator – trucks

The production processes of the material loading by excavator in the truck emit significant levels of noise that can be extended into the environment (Brigic et al. 2013: 3, Pleban et al. 2013: 8, Stanci et al. 2014: 10, Technical documentation of Mine Djurdjevik: 13). For the purpose of a comprehensive analysis of the noise impact of excavator systems on the ergonomic conditions of employees, adequate noise level measurements for EH 6/45, EŠ 10/70, and RB 195 turbochargers have been carried out. The noise emission of the excavator at different stages of the production cycles is periodically changed and estimated the impact of harmful effects on employees at the equivalent level. In order to assess the impact of production processes on working conditions on the open pit mine "Potocari", in the specific conditions measurements of noise, temperature and humidity during 2013 were made. For measurement, a measuring device digital multimeter - universal noise meter, temperature and humidity, PCE - EM886 was used. Two devices (the second as control) were used for the measurement, which during the entire measurement showed identical measurement-results. The results of measurements by different production processes and at different distances from noise sources are recorded in suitably prepared tables (Zenunovic 2016: 15).

On the basis of the measuring sizes, a distribution map, ie a map of noise, temperature and humidity is made. The results processing and display were made using the software GOLDEN SOTWARE SURFER 8.0, and the obtained images are given below.

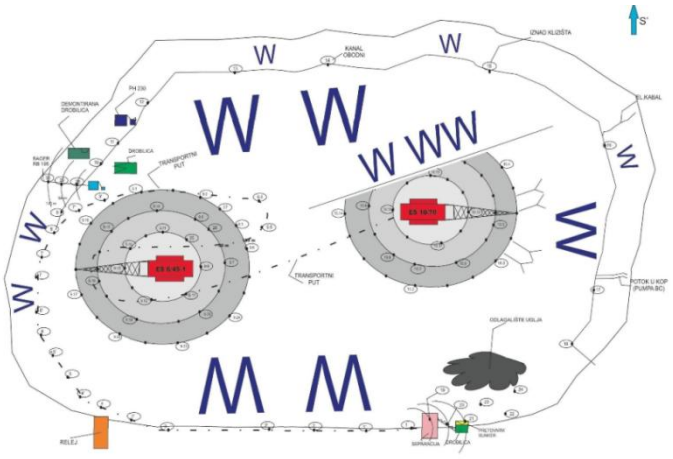

Figure 3 Position of the measuring points around the excavator ES 6/45 and ES10/70

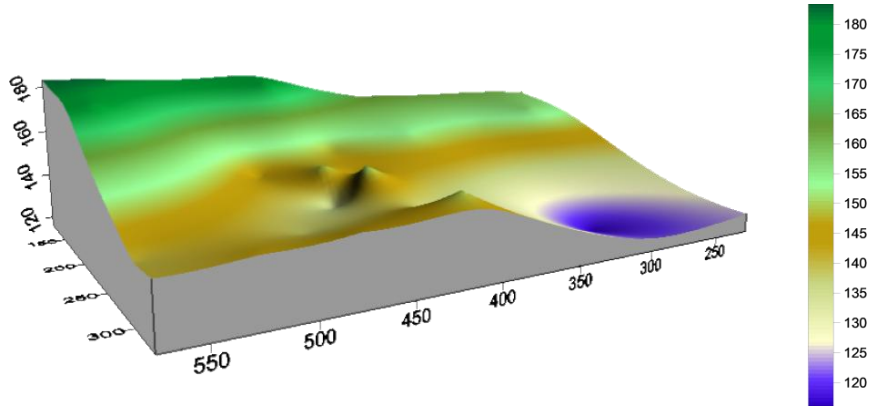

Figure 4 Display of the terrain in the immediate vicinity of the ES 6/45 excavator

Table 3 Measured noise intensity, temperature and humidity around ES 6/45 excavator

Measuring location	Noise level dB	Date	Time	Temperature ˚C	Humidity %	Point
excavator EŠ 6/45	83,7	08-11-13	12:05	28,6	41	25
radius 50 m	71,4	08-11-13	12:15	28,2	43	26
radius 100 m	66,6	08-11-13	12:30	29,1	44	27

Based on the table 3 which consist on the measured noise, temperature and humidity data around the ES 6/45 excavator in different positions of the measuring points, the maps of distribution of measured values have been created and presented on figure 5 and 6.

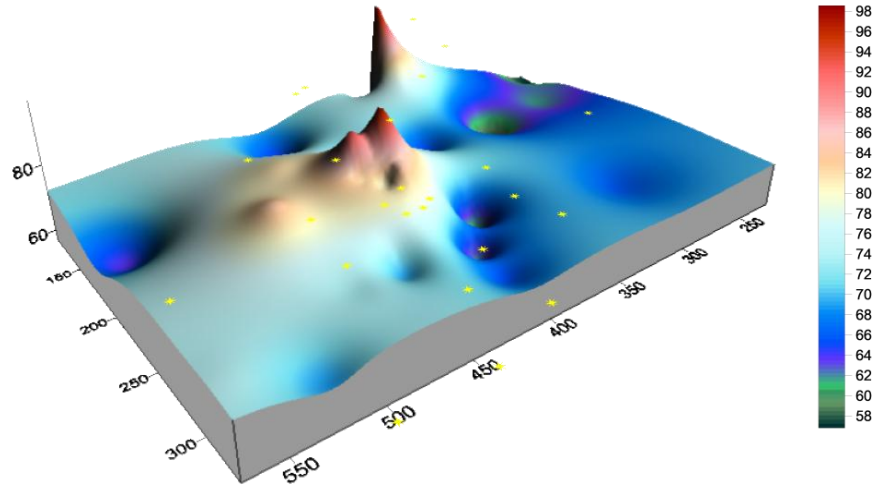

Figure 5 Distribution of noise (dB) around the excavator ES 6/45

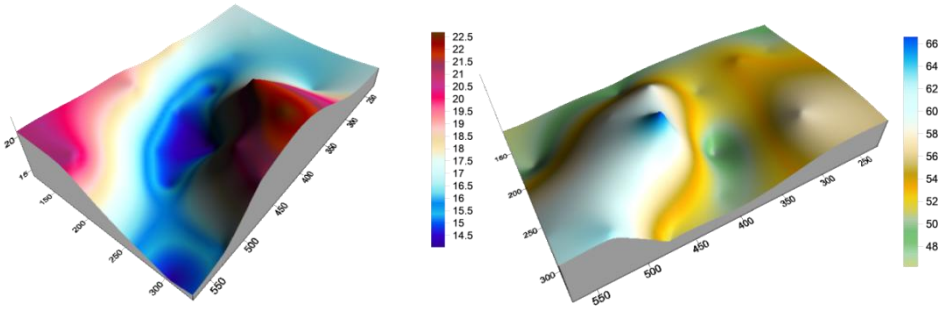

Figure 6 Distribution of temperature (left) and humidity (right) around the excavator ES 6/45

The terrain around the ES 10/70 excavator is shown in the following figures.

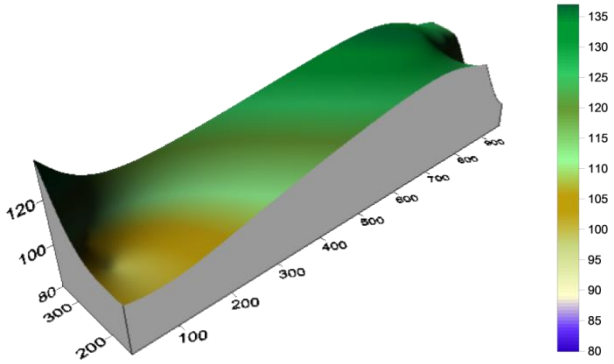

Figure 7 Display of the terrain in the immediate vicinity of the excavator ES 10/70

The noise, temperature and humidity around the ES 10/70 excavator during its operation are shown in the figures 8 and 9.

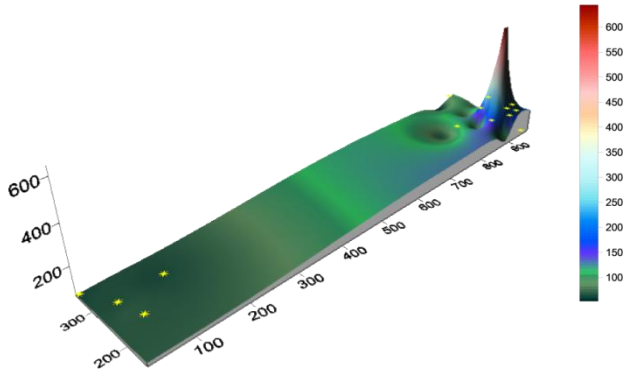

Figure 8 Distribution of noise (dB) around the excavator ES 10/70

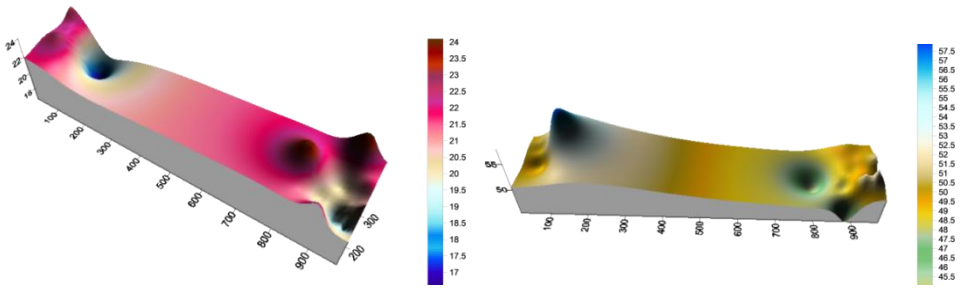

Figure 9 Distribution of temperature (left) and humidity (right) around excavator ES 10/70

Table 4 Measured noise intensity, temperature and humidity around RB195 excavator

Measuring location	Noise level dB	Date	Time	Temp. ˚C	Humidity %	Point
excavator RB 195	85,5	08-11-13	13:00	23,6	49	28
dump at internal landfill	66,2	08-11-13	13:05	22,4	46	28
operation of the excavator without moving	83,1	08-11-13	13:10	22	45	28
moving down a bench	83,6	08-11-13	13:15	23	46	28
radius 50 m	68,3	08-11-13	13:20	25,3	46	29
dump	99,8	08-11-13	13:25	25	47	29
radius 100 m	62,2	08-11-13	13:30	27	45	30

3.2 Results of measurements for auxiliary equipment on the open pit mine

The exploitation of mineral raw material on the surface mine is based on harmonized production processes of basic and auxiliary machinery. The production processes of auxiliary equipment on the open pit mine consist of:

- maintenance of transport communications-route and of plateau of the operating area,
- landfill planning,
- drilling the rock mass, and
- drainage of water from the crater of the pit mine and other.

Since the noise of the production processes of auxiliary machines on the surface mine at different stages of the cycle is periodically changing, the impact of harmful effects on employees at the reference, equivalent level is estimated. In table 5 and 6 are presented measured data for noise, temperature and humidity around bulldozer and loader when operating at the open pit mine (Zenunovic 2016: 15).

Table 5 Measured levels of noise intensity, temperature and humidity for the bulldozer

Measuring location	Noise level dB	Date	Time	Temperature ˚C	Humidity %
radius 100 m	58,8	29-10-13	12:40	35	33
radius 50 m	71,6	29-10-13	13:00	35	31
nearby bulldozer	99,7	29-10-13	13:15	34	32

Table 6 Measured levels of noise intensity, temperature and humidity for the loader

Measuring location	Noise level dB	Date	Time	Temperature ℃	Humidity %	Point
loader	102	8-11-13	11:00	17	56	23
radius 50 m	90,2	8-11-13	11:10	17	52	19
crusher when receiving hopper	89,9	8-11-13	11:15	25,8	43	23
radius 100 m	75,2	8-11-13	11:20	24	45	24
moving down	98,1	8-11-13	11:22	25	50	24

3.3 Results of measurement of noise, temperature and humidity during truck transport

The primary noise of truck transport is aerodynamic and mechanical origin. In internal combustion engines due to oil expansion in the engine cylinders, there is aerodynamic noise, which increases with the burn out of burned gases. Additionally, the noise of the same origin occurs on the suction side of the engine. Mechanical noise is caused by the vibration of the motor and other truck parts caused by motion in the engine, operation of the fan and other devices. The noise of the truck moving in the downhill route consists of the aforementioned low-intensity factors, but with the dominant noise levels of the electric braking system. Truck transport noise is periodically changing, and the impact of harmful effects on employees at an equivalent level, which is a constant impact, is

estimated, but is adapted to the variable level of the emitted noise by the harmful effect (Brigc et al. 2013: 3, Pleban el al. 2013: 8, Stanci et al. 2014: 10, Zenunovic 2016: 15).

Table 7 Measured values of trucks along the route on the open pit mine "Potocari"

Measuring location	Noise level dB	Date	Time	Temperature ˚C	Humidity %
In the line of route	92,2	29-10-13	10:55	36,3	32
Curve	76,4	29-10-13	12:04	35,4	30
Uphill	99,3	29-10-13	12:30	37,5	32
Downhill	66,5	29-10-13	12:54	36,3	33

Truck transport on surface mines emits significant noise in the environment. Since the noise is decreasing with increasing distance, in order to examine the situation, it was conducted tests and measurements of the noise level of truck transport at different locations. The purpose of this paper is to provide a basis for evaluation of the impact of noise on environment during transport by trucks. In table 8 and figures 10, 11 and 12 presented values of measured data of noise, temperature and humidity around separation plant at mine Djurdjevik (Zenunovic 2016: 15).

Table 8 Measured intensity of noise, temperature and humidity around separation plant

Measuring location	Noise level dB	Date	Time	Temperature ˚C	Humidity %	Point
separation	80,2	08-11-13	10:38	15	66	19
radius 50 m	66,5	08-11-13	10:45	17,8	56	20
loading at separation	84,9	08-11-13	11:05	17	54	21
operating of small truck	89,4	08-11-13	10:55	19,2	53	21
loading in wagons	84,8	08-11-13	11:10	19,8	52	23
radius 100 m	58,2	08-11-13	11:15	19	56	22

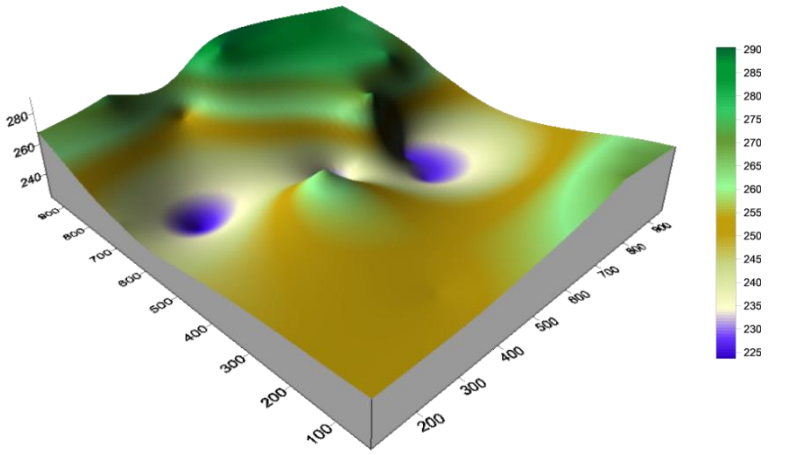

Figure 10 Display of a part of the open pit mine "Potocari"

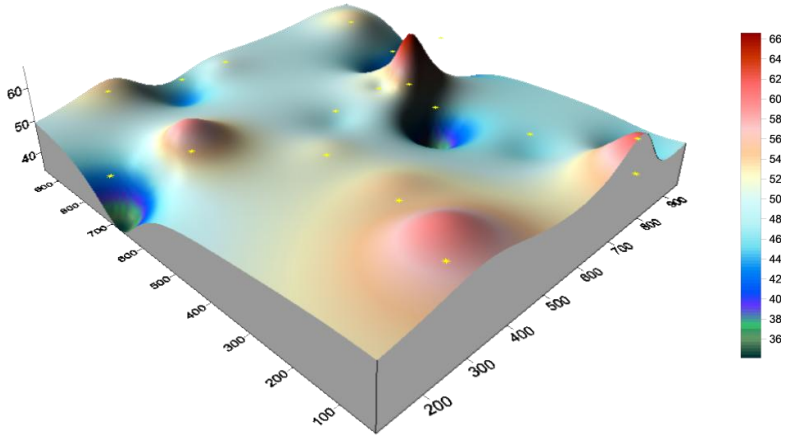

Figure 11 Distribution of noise (dB) during truck transport
in the open pit mine "Potocari"

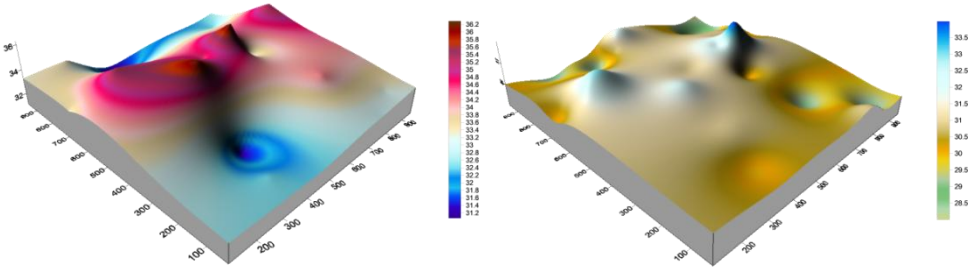

Figure 12 Distribution of temperature (left) and humidity (right)
during truck transport at the open pit mine "Potocari"

4. ANALYSIS OF MEASUREMENT RESULTS

Coal exploitation is a specific industrial brach that results in the emission "noise" in the environment. Noise sources include drills, blast explosions, crushers, heavy-duty trucks, belt conveyors, and noise from engines of other vehicles, machines and devices, auxiliary machinery and equipment. Permanent or sudden noise of higher intensity can lead to loss of hearing. In order to analyse the noise impact of the excavator's operation cycles on the ergonomic conditions of employees, the basic noise characteristics are presented, which by their influence violate the optimal conditions of the production process, and negatively affect the health of employees (Zenunovic 2016: 15).

For the tabulated measurement results, it can be concluded that the measured noise level in the immediate vicinity of the loaded Belaz damper (capacity 136 t) along the horizontal track is 92.2 dB, in the curve of 76.4 dB, at a rise of 99.3 dB, 66.5 dB. The measured level - the noise intensity in the immediate vicinity (in the excavation - block) for the RB195 excavator ranges from 66.2 to 99.8 dB. The noise level of the ES 6/45 excavator excavation ranges from 66.6 to 83.7 dB. The noise intensity in the immediate vicinity (in the excavation) for the ES 10/70 excavator ranges from 52.4 to 82.9 dB. The intensity of the noise level for the bulldozer was also monitored, and the noise was recorded in the interval from 58.8 to 99.7 dB. The measured intensity - the noise level for the loader in operation is from 75.2 to 102.0 dB. Depending on the distance of the measuring point from the source of noise, the intensity of the noise from 58.2 to 89.4 dB was recorded for the separation plant at the open pit mine "Potocari". In order to obtain as many reliable data as possible on the level of noise in the excavation, the measurement of the noise intensity around the active part of the open pit mine "Potocari" was performed, with a variation of 34.1 to 66.7 dB.

5. DISCUSSION

In this paper the influence of production processes on working conditions in a surface mine on the example of the open pit mine Potocari was considered. Although the working conditions are evaluated by looking at a number of influential parameters such as temperature, humidity, air quality (gas content, dust and smoke), lightening and vibration, the focus of work is to examine the presence and intensity of noise, i.e. "pollution" by the noise.

The noise intensity is constantly present and "burdens" the working conditions on the surface mines. It occurs as a result of a series of production processes, i.e. mechanization and equipment used in the execution of it. The consequence is the operation of drills, mining, and then the operation of excavators for digging and loading, trucks and rollers of rubber conveyor belts for transport, bulldozers and graders in the execution of a number of auxiliary processes pump operation, etc. (Aloui et al. 2016: 1, Bafeni&Kosasan 2009: 2, Pleban et al. 2013: 8, Stanci el al. 2014: 10, Hegley 2011: 6, Department of Economic DJTR 2015: 11).

6. CONCLUSION

Based on the results of the measurements, a general conclusion can be drawn that there is an overstepping of the permissible noise level, but this noise is short-lived, so that it does not have any harmful consequences. In the vicinity of mobile machines (trucks, bulldozers), except direct operator, there are not workers which would have long-term consequences from the noise. At places where the noise level exceeds the allowed intensity - "threshold", adequate protective equipment has been applied (Simonovic et al. 1982: 9).

All types of soil and other materials that provide stability can be used to create embankments as a barrier to noise protection. To stabilize the bulkheads - noise barriers, it is necessary to anticipate the appropriate materials. Dikes made of soil noise protection materials should be barriers to noise, which can be combined with the environment to the maximum extent possible by means of greening (Drincic et al. 2008: 5, Masovic 2015: 7, Simonovic et al. 1982: 9).

The ores are a national treasure and non-renewable resource, and mining is an extensive and complex branch of technology, without which the survival of civilization is unthinkable. Intensive industrial development entails an increasing need for the exploitation of mineral resources, especially energy resources, and imposes the need for a balanced approach in meeting social and economic needs from one, but also the need to preserve the environment on the other.

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