ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering
Tome XV [2017] – Fascicule 1 [February]

ISSN: 1584-2665 [print; online]
ISSN: 1584-2673 [CD-Rom; online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

[1.] Tale GERAMITCHIOSKI, [2.] Vladimir MIJAKOVSKI,
[3.] Vangelche MITREVSKI

CASE STUDY: ASSESMENT OF ENVIRONMENT POLUTION DURING CONSTRUCTION AND OPERATION OF SMALL HYDRO POWER PLANT SHEMNICA

[1-3.] University St. Kliment Ohridski, Faculty of Technical Sciences, Bitola, MACEDONIA

Abstract: Subject of this article is to review the condition of environment during construction and operation of small hydro power plant (SHPP) 'Shemnica' with ref. No. 267 in the village Malovishte, Municipality of Bitola, Macedonia. Possible negative impact on the environment will be assessed and measures will be determined in order to protect the environment during construction and operation of the SHPP for the needs of the Company ENERGOREMONG-MZT-Herz DOO Bitola. The case is even more specific since the location of the SHPP is in the National Park (NP) 'Pelister' that is protected by the Law with very strict regulative and standards regarding changes in environment during construction and operation phase.
Keywords: environment, hydro power plant, protection measures, noise, dust, waste

INTRODUCTION
One of the objectives in the development of water management of Republic of Macedonia is full and rational utilization of the hydro potential of waterways within multifunctional systems. Of the total usable hydro potential in the country, some 30,5% have been used so far. Construction of small hydro power plant on the river Shemnica represents realization of the objectives of Spatial Plan of the Republic of Macedonia for rational and full utilization of water resources in the country. Small hydro power plants can be built independently, at places where they would not endanger conditions for realization or functioning of greater regional energy systems.

Assessment for pollution coming from SHPP Shemnica, located in the vicinity of NP 'Pelister' and its influence on the environment with description of current situation of the environment regarding natural-geographic characteristics of the area, climate-meteorological conditions of the area and condition of three media, namely air, water and soil.

MATERIAL AND METHODS
Natural – geographic characteristics of the area
Location of the SHPP is approximately 20 km from the city of Bitola, south from the village of Malovishte, at an altitude between 1099,24 and 1255,55 m.

This location is completely inside the borders of NP 'Pelister'.

Hydrogeological characteristics of the area
Hydrogeological characteristics of the researched location depend upon morphological characteristics of the terrain, geological composition and climatic conditions. From the hydrogeological point of view, the complete area

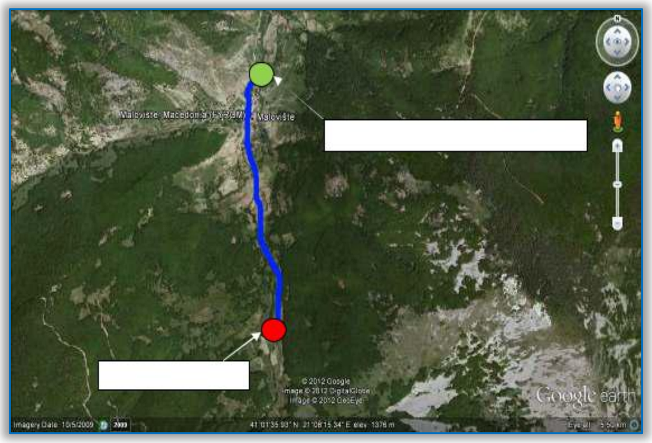

Figure 1. Satellite image of the location of SHPP 'Shemnica'

of the researched location belongs to the Vardar basin, which, as a main water artery accepts waters from the surrounding smaller rivers. One of the most important rivers in this area is river Shemnica with its smaller tributary Malovishka that has flow of 1-2 m^3/sec, depending on the time of flow measurement, i.e. it is larger during winter and lower during summer months. Remaining water flows that can be found at the researched area are temporary and ran dry during summer period. Within the investigated area, along the route of the pipeline, several water sources at different elevations with small yields are also registered.

From the hydrogeological aspect, solid rock mass: series of green shales and metagabbro have low water permeability, are characterized with slight porosity and high values of filtration coefficient represented with blocks with sandy gravel and as a part of deluvial sediment represented by sandy grains. Hydrogeological insulators from friable rock mass include certain part of deluvial built mostly from sandy and clay dust, characterized with capillary or super-capillary porosity and poor filtration characteristics.

Influence of climatic elements (temperature, humidity, solar insulation, cloudiness, precipitation, wind, etc.) and climatic factors, affect the development and existence of the entire living world, complete human activity and certain processes in nature, as significant element in the biosphere [1], [2],[3]. In the Republic of Macedonia two climate types prevail – Mediterranean and Continental. Therefore, two specific seasons exist: cold and wet winter, characteristics of Continental climate and dry and hot summer that corresponds to Mediterranean climate. Apart from Mediterranean and Continental, in higher mountainous areas, mountain climate occurs, characterized with short and cool summer and pretty cold and medium wet winters where precipitation is usually in a form of snow.

IMPACT OF SHPP 'SHEMNICA' ON THE ENVIRONMENT

Harmful effects vary in intensity, spatial distribution, diversity and duration of the impact. Result of these harmful effects is usually degradation of the entire eco-system through pollution and devastation of soil, water and air.

✓ **Influence on the air**, expressed through:

≡ Air pollution by flying dust fractions (solid particles), emission of harmful gases (CO_2, NO_x, CO, etc.);
≡ Change of microclimate and creation of zones with specific microclimate, different than the climate of the surrounding area;
≡ Noise as specific factor of environment pollution, both from the psychological (comfortable) and physiological aspect.

✓ **Influence on the water**, expressed through:

≡ Change in regime of underground and surface waters;
≡ Possibility of migration of some harmful components causing pollution of surrounding underground and surface water flows;

✓ **Influence on the soil**, expressed through:

≡ Change in micro relief and orography of the terrain as a result of which there is change in landscape;
≡ Taking up of valuable agricultural land;
≡ Change in paedological and geological composition of the soil;
≡ Destabilization of natural orographic structures and buildings constructed on the surface, due to the action of seismic effects;
≡ Waste generation.

Influence on the air, water and soil, which are basic bearers of the entire living world, lead directly to changes and cause damage, i.e. degradation of flora and fauna, either created by nature or created by humans.

Air emission – emissions of gases and dust

Air emissions, according to the Law on protection against pollution, are categorized as: emissions from boilers, stationary emissions from stationary and mobile sources and potential and fugitive emissions [3],[4]. Air emissions during the construction of the project are more intense with the increased presence of machinery on site. These emissions are of temporary character and will not have serious impact on the environment. Dust occurred during excavation for project implementation, as well as during ground clearing.

It can be noted that the main effect from gas and dust emissions at the location during construction phase are intense, but without permanent effect. In the operation (exploitation) phase, no harmful air emissions were recorded.

Internal combustion engines running on diesel fuel emit exhaust gases containing cca 180 organic compounds as harmful substances. Lead content in gasoline is up to 0,6 g/l. Approximately 75% of lead content is emitted through exhaust gases and cca 95% of sulphur content is burned to SO_2.
Contents of part of emitted harmful substances is given on Table 1.

Table 1. Contents of part of emitted harmful substances

Compound	Gasoline Engines	Diesel Engines
	g/l	g/l
Sulphur dioxide	0,4	4,5
Nitrogen oxides	20	90
Organic volatiles	40	110
Total suspended particles	3	15
Carbon dioxide	220	90
Lead	0,45	0
Benzo pyrene	20 mkg/m3	10 mkg/m3

Table 2. Maximum permissible concentrations (MPC) for harmful substances

Compound	Emission quantity	Emission concentration
	MPC (g/hour)	MPC (mg/m3)
Lead	25,00	5,00
Nitrogen oxides	50000,00	500,00-800,00
Hydrocarbons		500,00
Formaldehyde	100,00	20,00
Solid particles		130,00
Carbon monoxide		650,00
Carbon dioxide (%)		2,50

Long-term exposure to toxic substances mentioned above, adversely affects human health: smoke affects the respiratory system and skin, lead affects respiratory, nervous and blood system, nitrogen oxides cause asthma, allergies and cancer. Carcinogenic effects are also caused by solid particles from burning. Maximum permissible concentrations (MPC) for harmful substances are given in Table 2.
Use of environmentally friendly fuels that are currently being introduced in petroleum products retail, will drastically help to reduce the negative environmental impacts. Green belt around the object as a natural filter will also contribute to the reduction of the alleged air pollution.
Conclusion: From the operation of the facility it is established that there are NO volatile organic components (VOC).

Emissions to water and sewage

From the description of the project with its activity and the technological description of the activity performed, we can conclude that during the operation of SHPP 'Shemnica' there will be no technological process that will cause occurrence of wastewater.
During construction of SHPP 'Shemnica' wastewater appeared in from sanitary character from the employees of SHPP. Mobile toilets TOIFOR were used. For sanitary needs expected average daily production of wastewater ranges from 50 - 120 liters per person. According to available data, for smooth operation of this capacity, there are 25 employees in the company.
According to above mentioned standard average production of 120 liters per person, in total the daily production of sanitary wastewater reaches maximum of 3 m^3.
Average physical condition of wastewater from this sources, based on correlation with average quality of canal water would be as presented in Table 3 (in g/l).
During the construction of SHPP 'Shemnica' there was no impact on groundwater since the construction predicts only shallow excavations.

Table 3. Average physical condition of wastewater in g/l

matter type	mineral	organic	Total	BPK-5
Suspended	230	590	820	385
a) deposited	135	360	495	180
б) non-deposited	95	230	325	205
Dissolved	725	725	1450	110
TOTAL	955	1315	2270	495

Operability of SHPP could result with minor potential impact on water quality, especially during maintenance activities and control of infrastructure and equipment.

Municipal Solid Waste (MSW)

During the construction of this capacity, very small amount of biodegradable solid waste was produced due to daily activities of employed persons, while it is not expected any production of solid waste during the operation because there will be no permanent staff in the SHPP.
Around 1 kg of waste per person daily, in a form of paper, plastics, food remains, tin and cardboard packaging are expected. Certain quantities of waste cardboard and plastic packaging of raw materials should be added to this type of waste.
Municipal waste will be collected in a metal container and will be taken over by the public utility company which operates in the municipality of Bitola, which will further be recycled or deposited at the city landfill.

Emissions to the soil

During preparatory works, minimum negative impact of the location due to humus removal and leveling of the terrain foreseen for construction of buildings (intake weir, pipeline, power house and auxiliary road) is expected [4],[5]. Material from the excavation, if the conditions allow, should be reused (for instance, to backfill the pipeline since it is underground), while the excess of soil should be deposited to a place allocated by the Investor.

Most adverse influences occur during the construction phase and are usually result of using the construction machinery. Having in mind the presence of construction machinery at the construction site, during construction works, there is potential danger of releasing fuel and oil and their penetration into ground (soil) thus causing direct groundwater pollution. This influence is of short term character and limited only to construction phase.

In exceptional circumstances, spillage of hydraulic oil can occur. The same is not present in larger quantities (~50 liters) and it would be gathered in concrete bathtub under the turbine. In case of spillage during transportation of hydraulic oil, it is planned to remove the top layer of contaminated soil and its transportation to a location allocated for such purpose. Contaminated soil will be replaced by a clean one. Continuous emission in soil are not expected during construction phase.

Conclusion: from all of the above, we can conclude that the object, subject of this article, does not contaminate the ground (soil).

Noise, vibration and non-ionizing radiation

Noise is every sound that is not wanted by the perceiver, because it is unpleasant, loud, or interferes with hearing [7], [9]. Sound with greater intensity, regardless of whether or not it is registered by the sensory system of humans (or animals) may have especially harmful influence on their organisms. This influence primarily reflects on the central nervous system, and through it, to other organs as well (including the heart and blood vessels, endocrine glands, etc.).

Because the investor plans to build SHPP 'Shemnica' using latest technology, but because the company is located outside of populated area and not surrounded by other objects, it is expected that the noise will be in accordance to the Law on protection against noise in the living environment (Official gazette of RM, No. 79/07).

Due to the fact that the object is located outside urban area – area with IV degree of protection against noise (Rulebook for location of measuring stations and measuring points, Official gazette of RM, No.120/08) noise emissions are expected to be lower than permitted according to the Rulebook for limits on noise levels in the environment (Official gazette of RM, No.147/08).

Level of noise emitted from the establishment has been measured and it is found that the level is in accordance to the Rulebook for preparation of elaborates for environment protection (Official gazette of RM, No.147/08) and with the Rulebook for limits on noise levels in the environment (Official gazette of RM, No.147/08).

RESULTS AND DISCUSSION

Measurement of dust in the occupational area

Dust measurement is performed with handheld dust detector DUSTMATE (Fig. 2), product of TurnKey, Great Britain. The instrument has nefelometar that collects air through a pump, while the dust is measured with laser beams. Instrument possesses built memory for data logging. Measuring range of the instrument is from 0 to 6000 $\mu g/m^3$, with particles of diameter 0,5 to 20 μm and possibility for measurement of total solid particles (TSP), PM10, PM2,5 and PM1,0.

Measurement of microclimate and physical hazards

Measurements are performed by means of specialized calibrated device for measuring of temperature, humidity, air flow, noise and illumination, product of METREL Slovenia, type MI6201 MULTINORM (Fig.3). This instrument also has built in memory that can record great number of measured values.

From the measurement results it can be concluded that there is a certain amount of noise that does not exceed the permissible values, but is quite close to it. The noise is continuous throughout the 24-hour operation of the power house where the turbine impeller is installed. This condition is not recommendable for the health of population living nearby, so certain constructive measures are required to diminish these effects.

In order to protect the environment at the part where, currently, mesh is installed, it is necessary to install panels for noise protection.

Protection for air pollution

Anti-dust protection should be carried out by spraying water on roads and the construction site during dry weather. Planting lush vegetation around potential sources of contamination is a natural dam against emission of particles into the surrounding living space.

Water protection

1. To be careful for leakage when working with oil, and to dispose waste properly;
2. Organization of construction site with cabins, toilets with organized maintenance;
3. Particular attention should be paid in order to avoid increased deposition of materials at river crossings;
4. For water protection inside hydro power plant, filters for purifying water are installed.

Figure 2. Results from the performed measurements of dust with the instrument Turnkey Dustmate

Figure 3. Results from performed measurements of noise in front of the powerhouse

Мерни места за бучава измерени во околина на МХЕЦ Шемница, бр. 267	
Мерно место	Измерена вредност во dB(A)
Мерно место - 1	52.2
Мерно место - 2	58.5
Мерно место - 3	54.6
Мерно место - 4	48.2
Мерно место - 5	47.1
Мерно место - 6	70.3

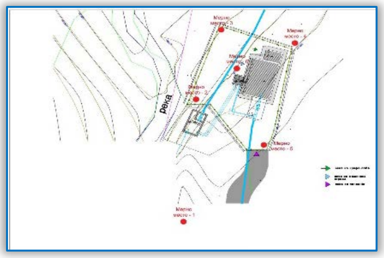

Figure 4. Measuring points for noise measurement in the vicinity of SHPP ‘Shemnica’

Waste management

1. Reduce of waste by the employees;
2. Signing of contract with the public utility operating in municipality of Bitola for taking and further management of non-dangerous waste;
3. Appropriate storage of dangerous materials near the barracks and their use during the construction. Installation and utilization of suitable system for deposition in order not to harm the environment.

Figure 5. Setting up a structure for stacking the panels for noise protection

Flora and fauna protection

1. Fencing of construction site in order to enable safe passage of animals;
2. Covering of pipeline and reinstating the route to its original condition;
3. Reducing plants cutting, as much as possible, along the route of the pipeline;
4. Restoring vegetation cover with native species;
5. Maintaining minimum river water flow;
6. Use of existing access roads/minimize the construction of new access roads.

CONCLUSION

The subject of this article is to explore the probability of endangering living environment during construction of Small Hydro Power Plant (SHPP) on river Shemnica. An analysis of the environmental ecosystem has been made. An analysis of technical equipment and construction of intake water weir on river Shemnica, pipeline and power plant has been made from the point of view of their impact on the environment. We made a retrospective of the theoretical potential sources of environmental pollution. Measurement of noise around the power house of the SHPP has also been made. We tried to establish a methodology for assessing the impact of the plant environment, whether it exists and if it does, which measures my assistance, by research. This methodology can be used for preparation of ecological elaborates for environment and ecosystem protection during operation of small hydro power plant. Analyzed example is typical because the subject SHPP is located in National Park 'Pelister', protected by the Law and with very high criteria regarding environment protection.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [10].

References

[1.] Abelson P.H., Biological Warfare, Science, 286(5445):1677, 1999
[2.] Allenby, B.R., Industrial Ecology: Police, Framework and Implementation, Chapter 1, Upper Saddle River, NJ: Prentice Hall , 1999
[3.] Babiker, M.J., Reilly and H.D., The Kyoto Protocol and Developing Countries, MIT Joint Program on the science and Policy of global change, Report No. 56, Cambridge MA: MIT, 1999
[4.] Freidlander S.H., Smoke, Dust and Haze: Fundamentals of Aerosol Behavior, New York, Wiley-Interscience, John Wiley&Sons, 1979
[5.] Gradel, T.E., On the Concept of Industrial Ecology, Annual Review of the energy and the Environment, 21:69-98, November, 1996
[6.] Godish, T.E., Air Quality, third edition, Boca Ration, FL: Lewis Publishers, CRC Press, 1997
[7.] Rulebook for preparation of elaborates for environment protection (Official gazette of RM, No.147/08), 2008
[8.] Project for construction and operation of small hydro power plant (SHPP) 'Shemnica' with ref. No. 267 in the village Malovishte, Municipality of Bitola, Macedonia
[9.] Rulebook for limits on noise levels in the environment (Official gazette of RM, No.147/08)
[10.] Tale Geramitchioski, Vladimir Mijakovski, Vangelche Mitrevski, Case study: Assesment of environment polution during construction and operation of small hydro power plant Shemnica, The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Zrenjanin, SERBIA, 2016