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ENVIRONMENTAL NOISE REDUCTION MEASURES IN CEMENT INDUSTRY: USJE CEMENT PLANT CASE STUDY

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Abstract. During 2013, AMBICON Laboratory, as a part of Faculty of Natural and Technical Sciences was engaged by TITAN Usje Cement Plant to conduct a noise control study in vicinity of Usje Plant, in order to identify and inventories noise sources within cement plant and marl quarry. For this purpose, at each noise source a 15 min noise levels measurement in one-third octave band were performed and source specific noise profiles were created. Using the noise profiles and Digital Ground Model for the plant and immediate vicinity, a Noise Dispersion Model was developed within SoundPLAN 7.2 software platform. Broadband noise level measurements at 20 points within the plant and 10 points located at most sensitive receptors in a plant immediate vicinity, were used to adjust and verify the model created. Using the data obtained TITAN-Usje and AMBICON joint teams develop a Noise Reduction Plan (NRP), describing protection measures and setting up priorities. In addition, and based on anticipated measures reduction levels, three stages (Realistic, High and Ultimate) were modelled using the same SoundPLAN 7.2 platform. After completing the first stage of the NRP and in order to confirm effectiveness of the actions taken, a follow-up study using the same methodology was conducted (2016/17). The paper presents the study approach and outcomes of the measures taken.

Keywords: noise, model, measures, measurement, environment.

AIMS AND BACKGROUNG

Noise is considered asaa very important part of environmental pollution, with a major negative impact on the life quality in urban areas. In an ever-moving modern world, noise originate from a wide variety of sources that includes traffic (air, roads and railways), industrial facilities and social activities[1]. Transport and industry are by far most frequent noise sources within urban areas[2]. Based on World Health Organisation (WHO) data, noise pollution was the third most dangerous environmental pollution, after exhaust emissions pollution and water pollution[3,4].

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In addition, large number of research and compliance studies in recent decades, indicate noise pollution as significant environmental issue, which pose a real threat to people's health and life quality[5]. Long-term exposure to noise may cause adverse effects on health such as annoyance, disturbance of sleep or daily activities, hearing disorders, hypertension and ischemic heart disease[6–11]. Furthermore, noise is not only danger for human health[12], but also have an impact on human performance[13] including reduced attention, and vigilance[14], reduced reading comprehension, short and long-term memory, job dissatisfaction and psychological disorders, making noise pollution not only health, but also socio-economic problem as well.

Although the noise pollution issues steadily grow, especially in developing countries, these problems are rarely addressed in a systematic manner and are most often overlooked because their effects are not sudden or striking[15]. In addition, noise pollution has been largely ignored in terms of its impact on health and wellbeing[16].

A TITAN Group Usje Cement Plant in Skopje, following their strong commitment to high environmental performance and Corporate Social Responsibility and Sustainable Development Policy in 2013/14 have engaged an AMBICON-FTNS Lab from Shtip, to conduct a Noise Control Study in order to identify noise sources within cement plant and marl quarry, determine their impacts on nearby residents and develop noise control/protection strategies. Based on noise level measurements at noise sources, a Noise Dispersion Model for cement plant and marl quarry, as well as their closest neighbourhood were developed. Working closely with plant engineers, a wide variety of control measures were modelled and based on effects obtained 3 different scenarios (Realistic, High and Ultimate protection level) were developed.

During the past 3years, the Usje Cement plant completes most of the noise control measures proposed in realistic scenario and follow-up study was conducted in order to asses effectiveness of measures taken (Usje Cement Plant and AMBICON Lab, 2016/2017). This paper presents the study approach and outcomes of noise reduction measures taken.

EXPERIMENTAL

Noise Control Study in 2013 (Ref. 17) has a phased approach starting from noise sources identification and profiling (measurements), noise modelling (DGM development, source modelling and maps generation), model verification and ending with control measures modelling, maps generation and scenarios development.

As a first step in a study development, a 15-minutes noise levels measurement in one-third octave band were performed and source specific noise profiles were created for all noise sources identified within the plant and the quarry. Noise measurements were performed in one-third frequency octave band according to ISO 1996 2:2010 Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels, using a Sound Level Meter type CR: 171C, an instrument Class 1 according to IEC 61762.

Measurements have been performed at 1.5 m height nearby noise sources and on most exposed facade of buildings at a 3.5 m distance from the buildings walls and other reflective surfaces[18]. Frequency analysis provide additional information about the noise source as well as about prevalence of certain frequencies, whether they are in humans hearing range.

Main noise sources within the marl quarry, as expected, involves heavy mining machinery like bulldozers, excavators, truck-tippers, primary crusher and marl transport conveyor[19,20]. Noise sources within cement plant include sources like blowers, mills, fans, filters and compressed air generators[17].

Noise levels for main sources within quarry range between minimal 64.5 dB for trucks and 98.6 dB for bulldozers, while in the plant the noise levels found occur between 82.5 dB for filters up to 100.2 for blowers (Table 1).

Table 1. Measured noise level close to main noise sources

Noise source	Measured $L_{eq,15min}$ (dBA)
Bulldozers	95.8–98.6
Excavators	78.8–81.2
Truck-tippers	64.5–69.7
Primary crusher	83.4–86.3
Transport conveyor	77.3–78.6
Blowers	98.3–100.2
Cement and raw mill	95.7–99.3
Fan	86.2–88.3
Filter	82.5–87.3
Compressor stations	83.8–86.7

Noise level data (source specific profiles) were embedded within digital ground model (DGM) for the plant, quarry and their closest neighbourhood, using the one of the most advanced Noise and Air Pollution Modelling Software, SoundPLAN 7.2. produced by Braunstein + Berndt GmbH/SoundPLAN International LLC (Ref. 21). The software future easy to use tolls for DGM development, noise sources approximation and contour maps calculation.

Digital ground model for area of interest and main noise sources within cement plant modeled with SoundPLAN 7.2 are shown in Fig. 1.

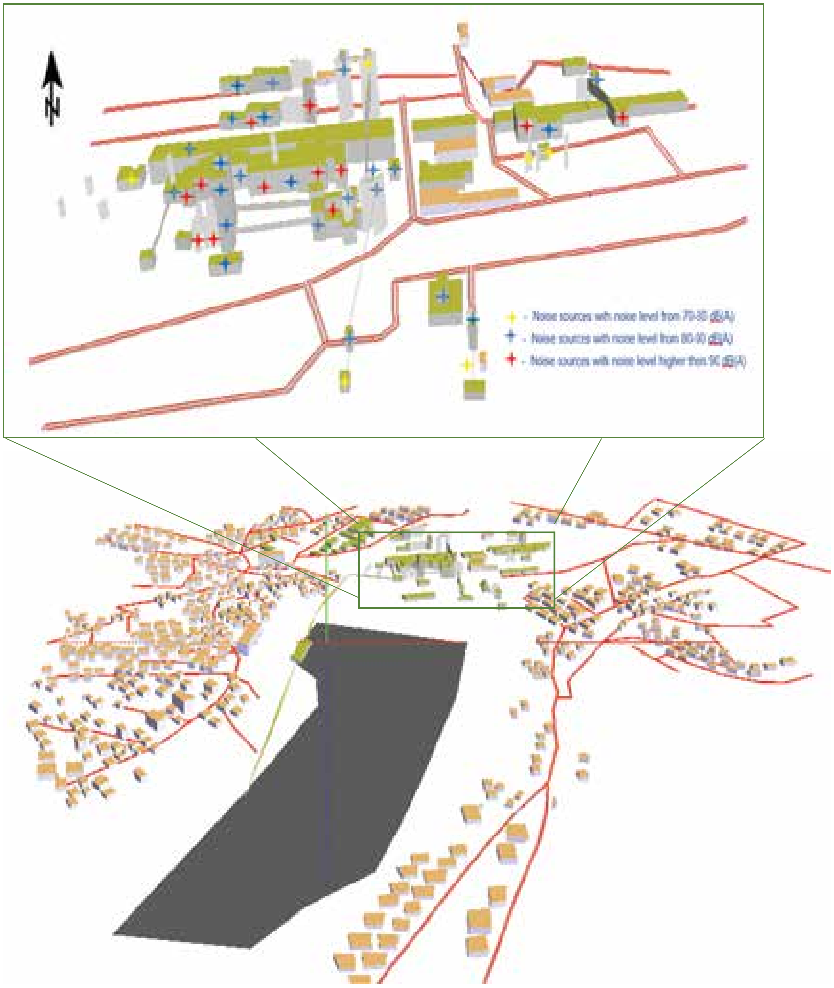

Fig. 1. 3D model of cement plant, quarry and their closest neighbourhood

Using the same software tools, noise dispersion (contours) maps for the area of interest were developed (Figs 2 and 3) and noise impacts assessed. Having in mind specific plant operation regime (daytime work in the quarry and no third shift in the plant), separate noise dispersion maps (2D and 3D) have been developed for the day and the night time.

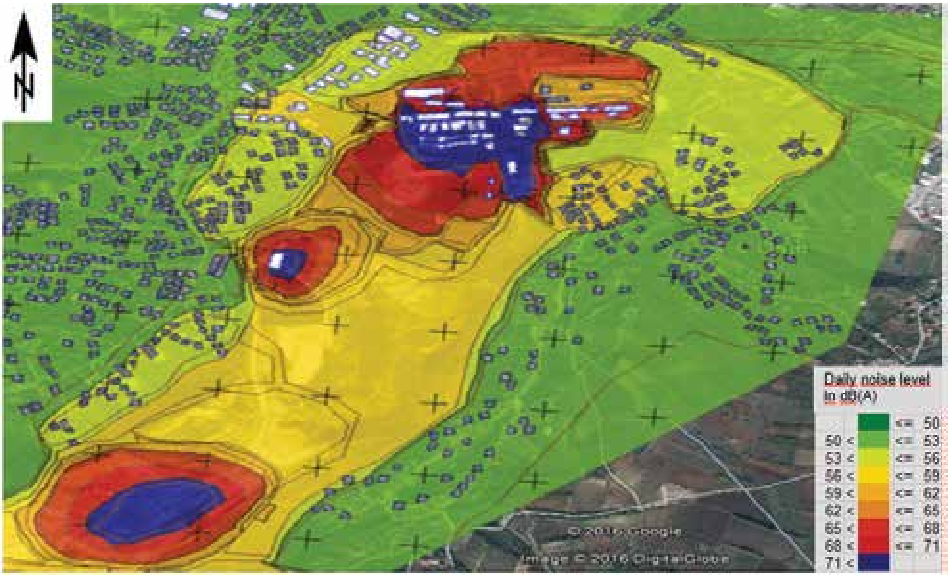

Fig. 2. Day time noise dispersion map (2D) for area of interest

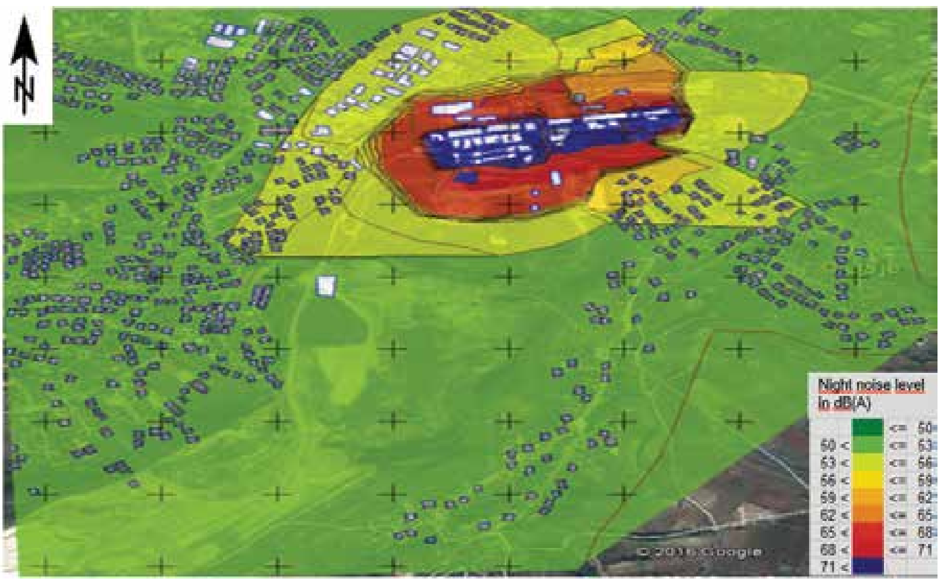

Fig. 3. Night-time noise dispersion map for area of interest

In order to verify the Noise Dispersion Model (NDM) developed, broad band measurements were taken at 20 measurement points within the plant and quarry area, and at 10 measurement points close to residents in their neighbourhood (Figs 4 and 5).

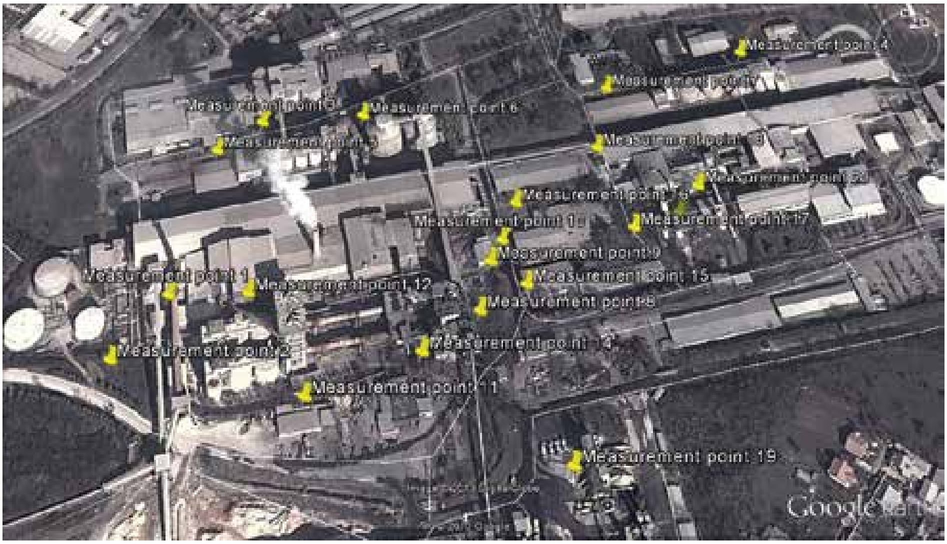

Fig. 4. Verification measurement points within the plant area

Fig. 5. Verification measurement points in the plant and quarry neighbourhood

Measured equivalent noise levels – L_{eq} (Equivalent noise level) were compared against modeled equivalent noise (Tables 2 and 3). Data presented clearly indicate excellent compliance between modeled and measured data. Small deviations that occur at individual measurement points are result of additional noise sources (mostly nearby roads) which were taken in account through noise dispersion model adjustment procedure.

Table 2. Comparison of measured and modelled equivalent noise levels (L_{eq}) within plant area

Measurement point	Measured $L_{eq,15min}$ (dBA), 2016	$L_{eq,15min}$ (dBA), according to the model
1	74.2	73–77
2	73.5	73–77
3	60.5	65–69
4	58.5	< 61
5	69.9	69–73
6	66.5	65–69
7	60.2	< 61
8	76.4	73–77
9	72.3	73–77
10	84.7	> 77
11	79.3	> 77
12	78.7	> 77
13	68.3	65–69
14	71.1	69–73
15	70.1	69–73
16	64.5	61–65
17	64.6	65–69
18	71.6	69–73
19	75.3	73–77
20	62.9	65–69

Table 3. Comparison of measured and modeled equivalent noise levels (L_{eq}) in plant and quarry neighbourhood

Measurement point	Measured $L_{eq,24h}$ (dBA), 2016	L_{eq} (dBA), according to the model
1	49.7	< 50
2	50.1	53–56
3	50.8	53–56
4	50.9	53–56
5	51.6	53–56
6	52.5	56–59
7	56.3	56–59
8	52.0	53–56
9	45.7	< 50
10	46.5	< 50

In the final phase, TITAN-Usje and AMBICON joint teams develop a Noise Reduction Plan (NRP), describing protection measures and setting up priorities. In addition, and based on anticipated measures reduction levels, three stages (realistic, high and ultimate) were modeled using the same SoundPLAN 7.2 platform.

Following the NRP (Ref. 17), TITAN Usje Cement Plant in last 3 years has taken most of the noise reduction and control measures as recommended in realistic scenario (Scenario 1). Most of the measures were taken at noise sources within the plant and vicinity of the marl quarry, and include: closing blowers in acoustic enclosure, purchase of new fans with lower noise levels, setting silencers on existing fans and exhaust openings, fencing noise sources (primary crusher, exhaust fan for kiln 3) with acoustic panels and setting acoustic louvers on compressed air station ventilation openings.

RESULTS AND DISCUSSION

In order to assess effectiveness after completing the NRP according the realistic scenario, a follow-up study was initiated during 2016/17, using the same approach as above. New source profiles were generated (measured) for all sources amended according the plan. New noise dispersion model taking in account reduction measures was developed and verified. Noise contour maps generated, clearly indicate significant noise reduction levels in zones where measures were taken. Significant reduction of day and especially night noise levels is evident at solid fuel preparation facility, packing plant No 2 and west side of pre-heater cyclone tower[21] (ellipse marked areas in Figs 6 and 7).

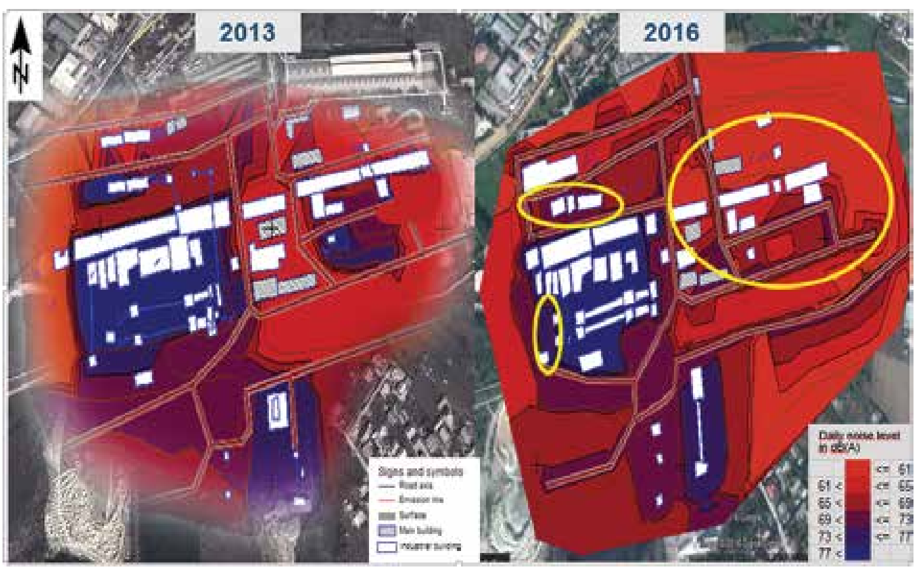

Fig. 6. Comparison of day time noise contour maps for plant area (2013 versus 2016)

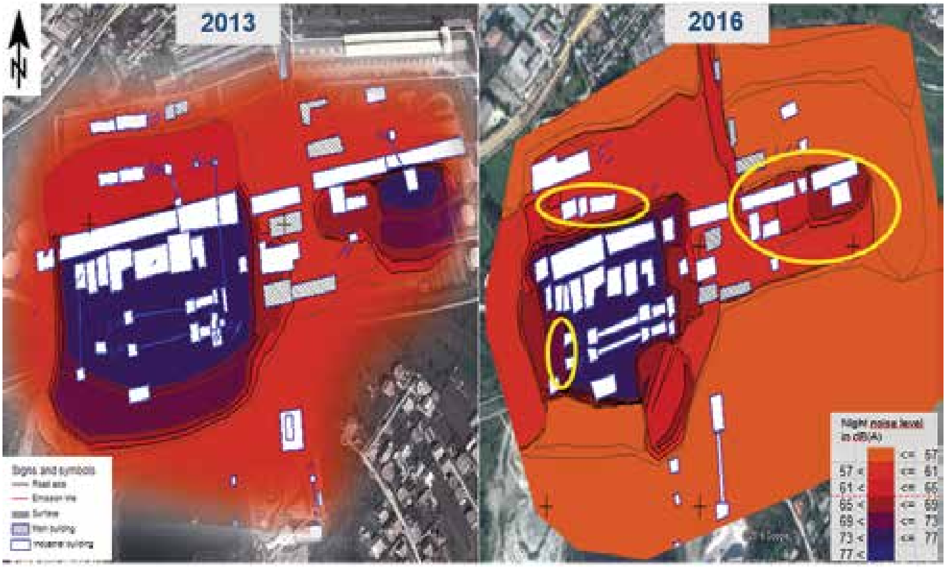

Fig. 7. Comparison of night time noise contour maps for plant area (2013 versus 2016)

In addition, comparison of contour maps modeled as realistic scenario (Scenario 1) in 2013 study (Ref. 17), with current noise contour maps (Figs 8 and 9) shows that wherever planed measures were completed, modelled noise levels are achieved or bellow planned and again prove good compliance between modelled and measured data.

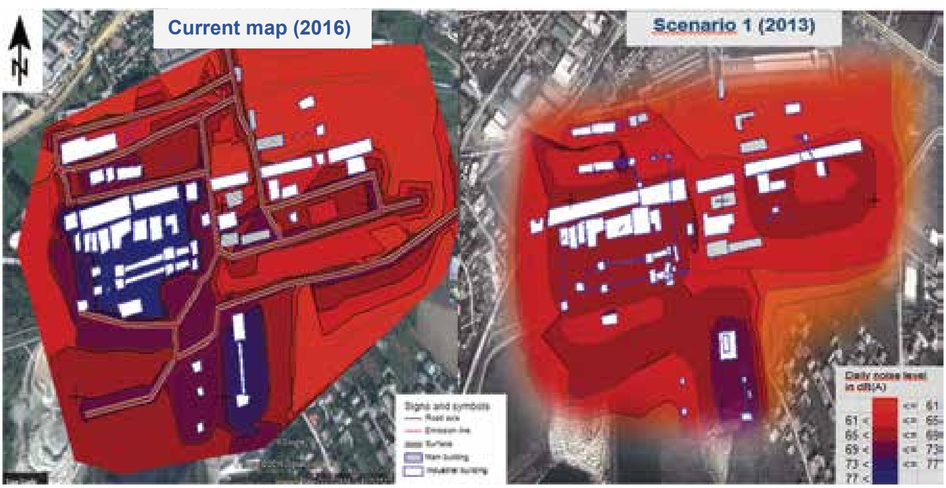

Fig. 8. Comparison of current day-time noise contour maps with realistic scenario map from 2013 study[17]

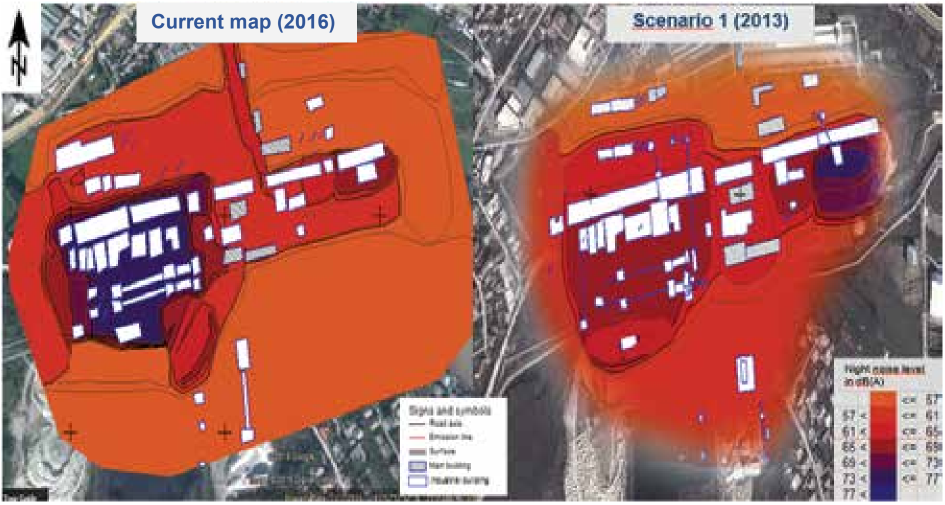

Fig. 9. Comparison of current night-time noise contour maps with realistic scenario map from 2013 study[17]

Results presented, proved approach taken as rational and effective pathway to reduce noise pollution impacts around industrial plants, even when located close to residential areas. Models show good compliance with measured results and can and should be used with confidence. This approach allows proper noise control measures planning and execution, as much as achieving noise levels within regulations limits.

Noise levels measured around the TITAN Usje plant and the quarry during the follow-up study prove that all disturbance indicators, daily, evening and night noise level (Ld, Lv and Ln) for all 10 control points in plant and quarry vicinity are within permissible limits (Fig. 10) according to Regulations of environmental noise level limits (Official Gazette of Republic of Macedonia, No 147/08). Very small exceedance (measured noise value is 0.7 dBA above permissible limit) is registered at measurement point 7, for Ln – night noise level which is A-equivalent long-term average sound level as defined in ISO 1996-2:1987.

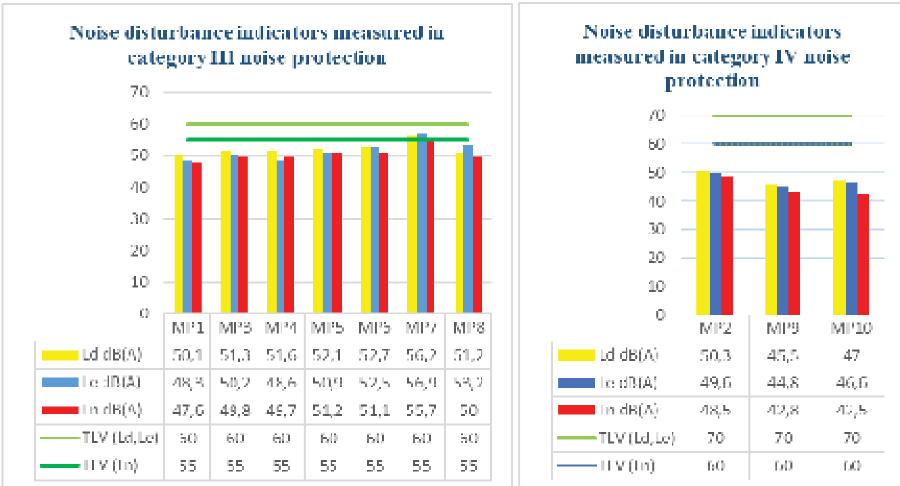

Fig. 10. Graphic review of measured noise level on 10 measurement points

CONCLUSIONS

Modern industry facing ever increasing challenges in reducing their environmental footprints and satisfying straighten regulations, especially for highly visible industries that draw public attention. We strongly believe Proactive approach example presented in this paper is to only way to address possible environmental issues in timely and efficient manner. TITAN Usje in Skopje initiate Noise Control Study well before and complaints or regulatory breach occur, plan and take corrective actions and confirm the results in a follow-up study.

Phased study approach starting from noise sources identification and profiling (measurements), noise modelling (DGM development, source modelling and maps generation), model verification, and ending with control measures modelling, maps generation and scenarios development, proved as rational and effective pathway to reduce noise pollution impacts around industrial plants. Models show good compliance with measured results and can be used with confidence. This approach allows proper noise control measures planning and execution, as much as achieving noise levels within regulations limits.

Current efforts on completing all measures in realistic noise control scenario and initiation of new plan for implementing balanced (cost/protection level) scenario (High Scenario), will assure that TITAN Usje Plant operate fully in line with national environmental regulations and continue to keep already good relations with the plant neighbors, as much as wider public acceptance as a social and environmentally responsible company.

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