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ANALYSIS OF THE ACOUSTIC CLIMATE AROUND THE SEWAGE TREATMENT PLANT IN LASK

Abstract
The aim of the study was the analysis of acoustic climate around the Municipal Sewage Treatment Plant in Lask. In the analysis, using computer program HPZ_2001 ITB, the calculations on the impact of the acoustic climate were carried out. In addition, to verify the calculations, current noise emission measurements during the operation of the wastewater treatment plant were made. The results found that during operation, the wastewater treatment plant does not teach exceeded permissible noise levels in adjacent areas under acoustic protection, both during the day and night.

Key words
sewage treatment plant, acoustic climate, noise

Introduction

The development of civilization is associated with the development of technology, which in turn produces frequent changes in the environmental that lead to the deterioration of its condition [1-2]. Noise is a form of pollution that may pose a health risk [3].

Environmental noise is more widespread than ever before and unfortunately it will continue to increase [4-5]. It is characterized by a multitude of sources and universality of occurrence in all biosphere systems. Noise refers to all troublesome, unpleasant or harmful vibrations of the elastic center [5]. Noise on the human body is bad and entails functional and health consequences [6-11]. The first group includes a sense of comfort and safety, the ability to communicate with the environment, the orientation in the environment. The second group includes general health, mental state or generally damage the hearing organ. Environmental noise can worsen the quality of life and generate sleep problems [12-16].

The main factors affecting high noise levels in cities are [17-18]:

- compact, double-sided and high-rise buildings in the city center (Canyon effects);
- poor technical condition of urban transportation;
- poor technical condition of the surface and tram tracks;
- high proportion of vehicles (trams, buses, trucks) in motion through-routes.

Figure 1 presents the division of types of noise depending on the environmental in which it occurs.

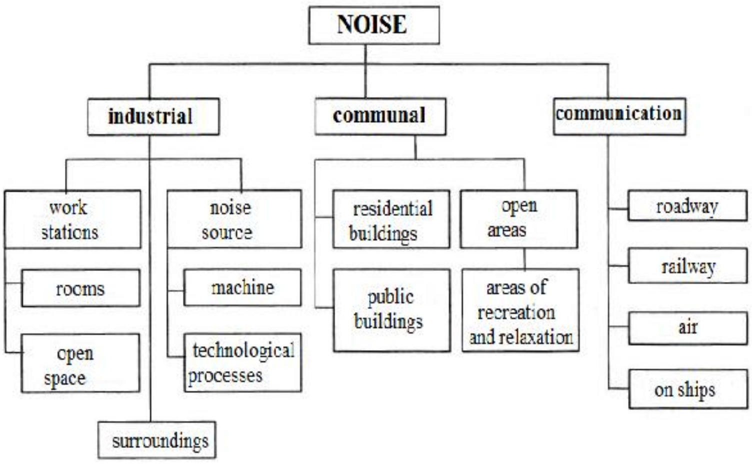

Fig.1. Types of noise depending on the environment in which it occurs
Source: [19]

This paper will analyze the acoustic atmosphere the municipal wastewater treatment plant in Lask in Poland. The waste treatment plant is an irreplaceable element of municipal functioning. The primary task of wastewater treatment is to protect the human environment and, above all, protect the purity of surface water [20-23]. An urban waste water treatment plant in Lask, is organized source of noise. The plant is located in the north-eastern part of city. In one day, the Grabia river gets an average of 6 000 m^3 of treated wastewater. [24].

To the north of the sewage treatment plants there are meadows and pastures, as well as undeveloped grounds adjacent to the Grabia river 500m from the sewage treatment plant. To the East there are meadows, pastures and undeveloped areas adjacent to Stefan Zeromski street (National Route 12 and Route 14), 830m away from the plant. To the west there are meadows, pastures and undeveloped areas adjacent to the Grabia river that are 650-1,200 m away from the sewage treatment plant. To the south there are residential detached houses along Jan Kilinski street.

Near the plant there is no cultural property subject to protection under the Law on the Protection of Cultural Property. The land area on which there are objects is 5.7869ha. This area has been fully converted to the current usage [25]. The 3.5m wide internal road system ensures free access to cubature and technological facilities. The majority of the area is covered with greenery.

A network of intersecting tubes includes sewage pipes (inlet and discharge), compressed air lines, raw sludge lines (excessive, interior scenes concentrated, fermented), and leachate from the drainage of platelet and filter presses.

The technology of the wastewater treatment in the plant is based on a two-stage method of removing pollutants. In the first stage the impurities are removed mechanically, and the second stage uses biological cleansing.

The plant includes preliminary clarifiers, a digester, a blower room, a sludge dewatering room, a sludge pumping station, biological reactors, secondary clarifiers, a thickener room, a wastewater pumping station and chamber bars, sub- plot sedimentary, a dryer and grit chamber.

There is a plan to reconstruct the wastewater treatment plant. The main aim is to increase the average to 8 000 m^3 per day. It will be equipped with an installation for biogas and a combination of heat and electricity for the needs of the enterprise. In addition, the treatment plant will be equipped with two sand removers (instead of the existing sandstone) and rich would be the existing preliminary and secondary clarifiers and biological reactors.

The main goals of the expansion include [27] reduced nuisance from the wastewater treatment plant, the application of renewable energy sources, increased efficiency and improved parameters of treated wastewater, connecting new customers to the sanitary sewage network, reduced emission of sewage to water and soil and limiting the entry of dangerous substances that threaten the lives and health of humans into the environment, halting the degradation of groundwater, increasing the investment and tourism attractiveness of agglomeration areas, improving the quality of life in the agglomeration, and increasing the satisfaction of the population.

Materials and methods

Noise measurements help you determine the environmental impact of your business [28-30]. The methodology to assess the environmental noise emitted into the environment is given in in the instructions no 308 and 338 Institute of Building Technology and State Inspectorate for Environmental Protection "Methods of measurement of external noise in the environment” [32] as well as in PN ISO 1996 -1,2, 3 [33-35] and PN-ISO 9613-1.2 [36-37]. The calculation method was based on the relationship between sound emission, characterized by equivalent sound power level of frequency-weighted sound power according to the "A" correction curve from the individual sources and the immission of the noise in the impact area, characterized by an equivalent level of sound "A". The weight scale “A” has been chosen because it is close to the characteristics of the human ear. The equivalent sound level "A" at the place of observation in the distance "r" from the center of a single source, shall be calculated in accordance with a dependency, with fallowing formula:

$$L_{A} \quad = L_{A} \quad + K_0 - \Delta L_B - 10\log(4\pi) - \Delta L_r - \Delta L_e - \Delta L_Z - \Delta L_p \; [d \quad (A)] \tag{1}$$

where:

- L_{AWeqi} – equivalent sound power level [dB (A)];
- K_0 - correction taking into account the impact of solid angle, equal to 10log(4⇍Ů) [dB (A)];
- L_B - correction including directional impact [dB (A)];
- L_r - correction taking into account the impact of distance [dB (A)];
- L_e - correction taking into account shielding [dB (A)];
- L_z - correction taking into account the impact of green [dB (A)];
- L_p - correction taking into account the sound absorption by air [dB (A)].

If the performer measurements apply to the sound level, sound power level is calculated according to the following formula (2):

$$L_W = L_m + 10\log\left(\frac{S}{S_0}\right) [d \quad (A)] \tag{2}$$

where: L_m =sound level; [dB (A)];
- S = *4(ab + ac + bc)(a + b + c)/(a + b + c + 2d)*, [m^2];
- *a, b, c* =dimensions describing the device test [m];
- S_0 = 1, [m^2].

Mobile sources emitting noise depends on the phase of the movement, and are calculated an equivalent level of acoustic power - L_{Aweqn} from the following formula (3):

$$L_{A} \quad = 10l(\quad \left(\frac{1}{T} \cdot \sum_{n=1}^{N} t_n \cdot 10^{0,1L_W}\right) \tag{3}$$

where: L_{AWeqn} – equivalent sound power for the n-th vehicle, [dB (A)];
- L_{Wn} - sound power level for this motor option, [dB];
- t_n - the duration of the mobility options, [s];
- N - the number of motor operations in time T, [dimensionless];
- T - time of observation for which the calculated level equivalent, [s].

Areas bordering sewage treatment plant subject to acoustic protection [31]:

- in a southerly direction permissible sound level A $L_{Aeq\,D}$= 55 dB and $L_{Aeq\,N}$= 45 dB areas for homesteads [32];
- towards the east, west and north the terms acceptable level of noise are absent.

For the wastewater treatment plants, the impact of equipment and facilities, as well as light and heavy vehicles, were identified.

For existing installations, the equipment or machinery located within the wastewater treatment plant [27]:

- waste water pumping station and chamber bars;
- grit chamber;
- the preliminary clarifiers;
- biological reactors;
- the secondary clarifiers;
- hygenisation station of sludge;
- blower room, sludge dewatering room, sludge pumping station;
- thickener room;
- digesters;
- the building of social administration.

The proposed installations, the equipment of machinery located within the wastewater treatment plant are [27]:

- sand removers;
- biological reactors;
- the secondary clarifiers;
- the sewage storage station.

Based on the above equations were calculated sound power levels for all noise sources. The results are shown in the Table 1. Below are presented the assumptions the calculation for light and heavy vehicles.

For mobile sources, it is assumed that 3 light vehicles will move a distance of 300 m and 10 heavy vehicles a distance of 800 meters. The total duration of the journey in the first case is less than 1 minute, and the second less than 1.5 minutes.

For calculations, the following values of the noise impact of light vehicles are used:

- driving at a speed 50 km/h (13,9 m/s) on Wojska Polskiego Street and detention at the administrative and social building, there is expect a value of: 99,5 dB(A);
- braking (3 seconds), there is expect a value of: 98 dB(A);
- moving (5 seconds), there is expect a value of: 100 dB(A).

For heavy vehicles, the noise values of the impact are as follows:

- driving at a speed 50 km/h (13,9 m/s) on Jana Kilinskiego street and 30 km/s (8,33 m/s) on waste water treatment plant, there is expect a value of: 105 dB(A);
- braking (3 seconds), there is expect a value of: 111 dB(A);
- moving (5 seconds), there is expect a value of: 101,5 dB(A).

Equivalent sound power level was 56,8 dB(A) for light vehicles and 72,2 dB(A) for heavy vehicles. The calculation of the acoustic climate impact was carried out using the computer program HPZ_2001 ITB. Calculations have been carried out only for the day, because there is then the impact of light vehicles and tankers (movement of vehicles between from hours 6 am and the hours 10 pm). Calculations were made for the two variants: an existing and taking into account the planned expansion.

Tab. 1. Equivalent sound power levels

Sound source	**Value [dB(A)]**
light vehicles	56,8
heavy vehicles	72,2
the building of social administration	64,0
building with separated fermentation chambers	76,9
wastewater pumping station and chamber bars	58,6
drainage station of sewage	74,0
sediment thickener	78,0
existing biological reactors	81,0
proposed biological reactors	64,0

Source: Author's

Impact of vehicles is referred to as an omnidirectional source. The impact of light vehicles was replaced by 24 replacement sources, and heavy vehicles with 29 replacement sources. In the case of expansion of the sewage treatment plant, there was a doubling of the number of cisterns. For the source of the sound, the following items were adopted: social administration building, building near separate sludge digesters, waste water pumping station and chamber bars, waste water sludge thickener station, the existing biological reactors and designed biological reactors. Acoustic screens include the existing digesters, designed digesters, two existing secondary clarifiers, garage, transformer station, a sieve-grit chamber, a trap, the secondary sedimentary plots of the trap, and the existing sludge. A calculation was made regarding the surrounding environment of the sewage treatment plant.

The calculations were made in a grid of observation points at a height of 4m and calculations of an isophone at a height of 1.5m, taking into account the nearest surroundings of the treatment plant. Measurements of current emission of noise were carried out to verify the calculations . The results are shown in Table 1.

Tab. 2. Current immission measurements of noise:

Place of the measurement	Value [dB(A)]	Uncertainty of measurement [dB(A)]
measurement of the digesters (opposite the blowers)	51,9	0,7
measurement at the existing the preliminary clarifiers (opposite biological reactors)	54,9	0,9
measurement at hall of the thickener (from the side of the building of social administration)	55,1	1,2

Source: Author's

Results
A computer simulated range impact on the climate was carried out based on the above calculation. The first variant was carried out from the variant of the current situation for existing equipment, buildings and 10 tanks. The second option includes all designer devices for expansion of the waste water treatment plant and a doubling of the cisterns.

The following were presented maps illustrating the isophone noise that determine the impact of the sewage treatment plants on the environment.

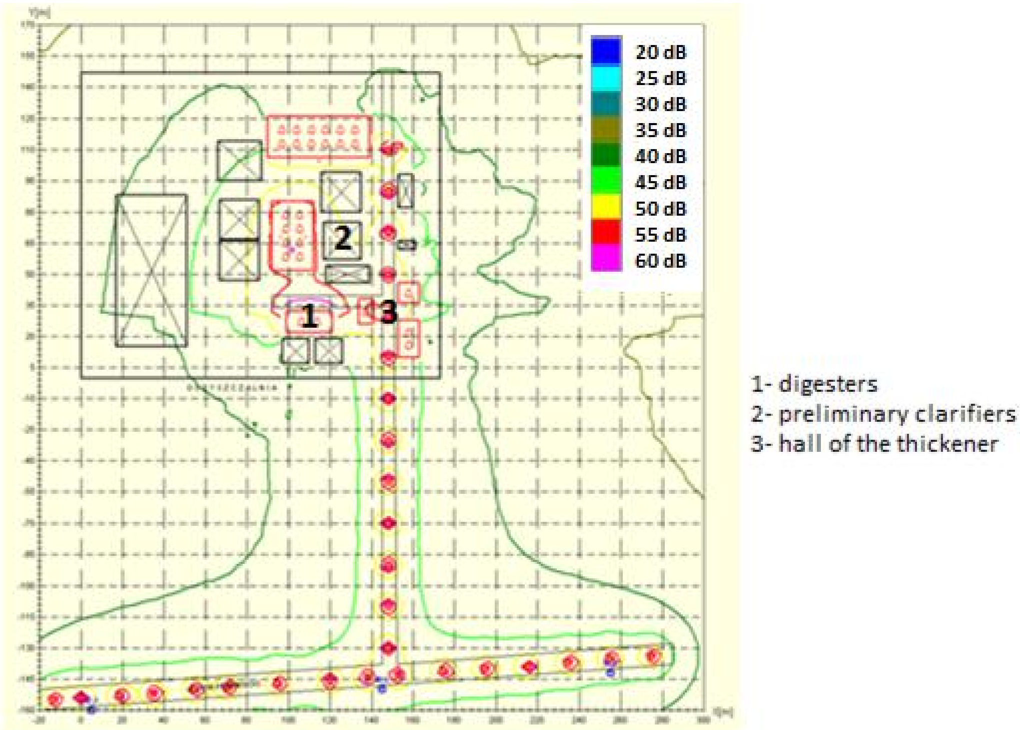

Fig. 2. The time of day, isophone height 1,5 m, height of observation points 4 m, the numbers of cars to the refurbishment 10.
Source: Author's

Figure 2 illustrates that the isophone of noise (equivalent sound level equal to 55 db(A)- red line) related to the impact of the airborne noise emitted by sewage treatment work, during the day, do not go beyond the area of water treatment plants. The projected emission values in the southern points of observation, located in protected areas values do not exceed the 48,6 dB(A), and consequently are lower than the limit value.

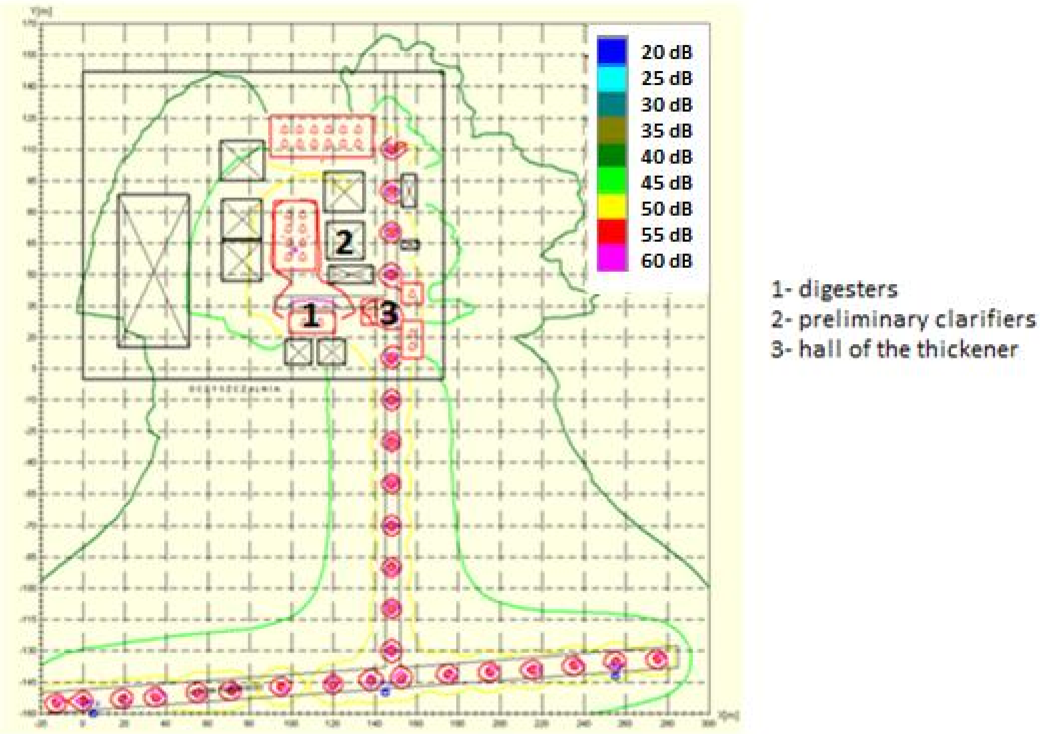

Fig. 3. The time of day, isophone height 1,5 m, height of observation points 4 m,
the numbers of cars to the refurbishment 20.
Source: Author's

In the case of a doubling of the number of cars to the refurbishment (Figure 3) is also not to leave out purifier noise contours expressed equivalent sound level 55 dB(A) in the time of day.

The projected emission values in the southern points of observation, located in protected areas values do not exceed the 51,6 dB(A), so are lower than the limit value.

Summary and conclusions

On the basis of the measurements and computer simulation carried out at the Municipal Wastewater Treatment Plant in Lask, we can conclude that the extent of the impact on the acoustic climate is acceptable.

On the acoustic protection areas equivalent sound level does not exceed the limit value in both cases of 55 dB(A). In the case of the current work the expected noise level in these areas will be 48.6 dB(A). In the case of the planned expansion and doubling the number of tanks the equivalent sound level in these areas will be around 51.6 dB(A).

It can be concluded that the work of the sewage treatment plant does not adversely affect the acoustic climate of the immediate vicinity. Reconstruction of technological devices and doubling vacuum trucks also will not adversely affect an environment.

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