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Empirical Approach to Measuring Noise as Environmental Nuisance of the Seaport Activity and Assessing Its Impact on Local Port City Community

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Abstract:

Purpose: *The basic aim of the study came down to measuring noise emissions generated by the port container terminal and defining its impact on the comfort of life of the residents of housing estate adjacent to the terminal.*
Design/Methodology/Approach: *A few research methods and techniques were applied: critical literature review, research questionnaire, comparative analysis, case study and noise measurement techniques.*
Findings: *The final research results regarding the measuring, monitoring and reduction of noise generated as part of 24/7 business activities within the port/terminal area, perceived in terms of its impact on the comfort and quality of life of port city residents, clearly indicate that noise is still one of the main nuisances for them and port employees. At the same time, however, the conducted research indicates that the inhabitants of the port city perceive this type of noise as the effect of the overlap of both the constantly relatively loud activity of the port as a busy transport hub and the broadly perceived transport activity carried out in relation to it and the port city.*
Practical implications: *Taking into account also the research results, indicating that the majority of residents living close to the port container terminal do not perceive port noise as the main factor adversely affecting the comfort of life during the daytime, it was possible to formulate conclusions and recommendations for the entities managing the port and terminal as well as city authorities regarding the reduction of port noise emission. They could contribute to the development of partnership relations between the seaport – residents – port city authorities.*
Originality value: *The conducted study aimed to find the causal relationship between various forms of port's noisy activity and its immediate surroundings, indicates the need not only for permanent cooperation between all directly interested parties but also creating a common crisis management platform in such a sensitive environment. Moreover, the adopted research methodology and the obtained results, allow to formulate clear recommendations regarding the development of a common environmental management strategy for the port and port city to create a synergy effect in this field.*

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1. Introduction

Since seaports represent areas with a high potential for pollution, including noise, the European Sea Ports Organisation (ESPO) among many other statutory forms of its activity, encourages the exchange of environmental knowledge and experience throughout the international port sector. As a result of ESPO's involvement in the field of ports environmental management, it has presented annual environmental reports (EER) since 2016.

The ESPO environmental report, which is a part of EcoPorts, regarded as the environmental flagship initiative of the European ports, provides ESPO and the European policymakers with insights into the environmental issues that the European ports are working on, and informs on initiatives taken by ESPO in this field (Giuffrida *et al.*, 2021; ESPO 2020; 2022).

EcoPorts was initiated by a number of proactive ports in 1997 and has been fully integrated into the ESPO since 2011. The overarching principle of EcoPorts is to raise awareness on environmental protection through cooperation and sharing of knowledge between ports and improve the already used environmental management.

The Ecoports Network is in fact an environmental platform of the European port sector developed by ports for ports, striving to self-monitor their environmental management and improvement over time and encouraging the free exchange of experience on environmental issues among its members.

In this way, EcoPorts strives not only to increase the awareness of environmental challenges and improve public health, but also to deliver compliance with legislation and to demonstrate high standard of environmental management amongst its 91 members from 26 countries (ESPO, 2024; EcoPorts, 2024). It should be emphasized that EER is an important tool of the ESPO- Ecoports Network, together with the Self-Diagnosis Method (SDM) and the Port Environmental Review System (PERS).

SDM is a concise checklist against which port managers can self-assess the environmental management programme of the port in relation to the performance of

both the sector and the international standards. Aggregated data from the SDM forms the basis of the annual environmental reports. On the other hand, PERS is the only port sector-specific environmental management standard developed by ports themselves (ESPO's Roadmap, 2020; ESPO, 2024; ESPO News, 2024). It does not only incorporate the main general requirements of recognised environmental management standards (e.g., ISO 14001), but also takes into account the port specificities. PERS builds upon the policy recommendations of ESPO and gives ports clear objectives to attain.

In this sense, PERS is seen as the EU's research initiative connecting the ESPO Network, port professionals, academia, and the maritime industry (ESPO, 2020). Its implementation and compliance with the EcoPorts' PERS standard are independently reviewed by Lloyd's Register. PERS certification is voluntary, and the certificate is valid for two years. EcoPorts' PERS is revised after the 2-year period to make sure that the port continues to meet the requirements.

The last five years have seen important increases in EcoPorts recognition and membership, with 91ports currently in the EcoPorts network, and 36 ports holding PERS certification, while 56 ports have ISO certification (EcoPorts, 2024, ESPO News, 2024). Such activity and its results are a clear manifestation of good practice implemented by EkoPorts and strongly supported by ESPO, leading to the improvement of the natural environment in seaports and their immediate surroundings.

This issue is the main area of the authors' research, however, focusing only on one of these nuisances, i.e. noise, presenting its impact on the local community living in the vicinity of the port of Gdynia. In its practical dimension, it refers mainly to container terminals that are a source of noise. This research is a case study.

2. Ports' Environmental Management Systems and Ecoports Initiatives as a Good Practice

There are three main internationally recognised Environmental Management Systems (EMS) standards: the EcoPorts' Port Environmental Review System (PERS), ISO 14001, and the Eco-Management and Audit Scheme (EMAS). In 2024, 75% of respondent ports have a certified EMS. Among these, nearly half have opted for ISO 14001 (47%), followed by the EcoPorts' PERS (18%), making ISO and PERS the most popular standards in the sector (ESPO, 2024).

Additionally, some ports hold certifications in more than one standard, such as ports with both ISO and EcoPorts' PERS (21%) or with the three certificates (10%) The recent EER of 2024 indicates that the European ports are enhancing their environmental management, with improvements in the Environmental Management Index (EMI). Together with the ESPO Green Guide 2021, the EER strengthens the long-standing efforts of the European ports to monitor and address high priority

environmental issues, among which port noise still plays a key role as environmental nuisance. The indicators also fall into PortinSights, which is ESPO's tool for the European ports to collect, share, compare and analyse their data.

The digital platform includes throughput data, environmental data (EcoPorts) and governance data (Wendling *et al.,* 2020; Hänninen *et al.,* 2014; EC, 2020; ESPO, 2021). The Environmental Management Index (ranging from 0 to 10), which provides an indication of the extent to which ports in the EcoPorts Network are engaged in the environmental management, has increased significantly in recent five years.

In 2013, the score was 7.25, in 2020 already 7.80 and in the last two years 2023 and 2024 it was 7.98 and 8.61 respectively. This improvement largely results from a growing share of ports providing environmental management programmes and training (WB and S&P Global, 2023, Notteeboom *et al.,* 2022).

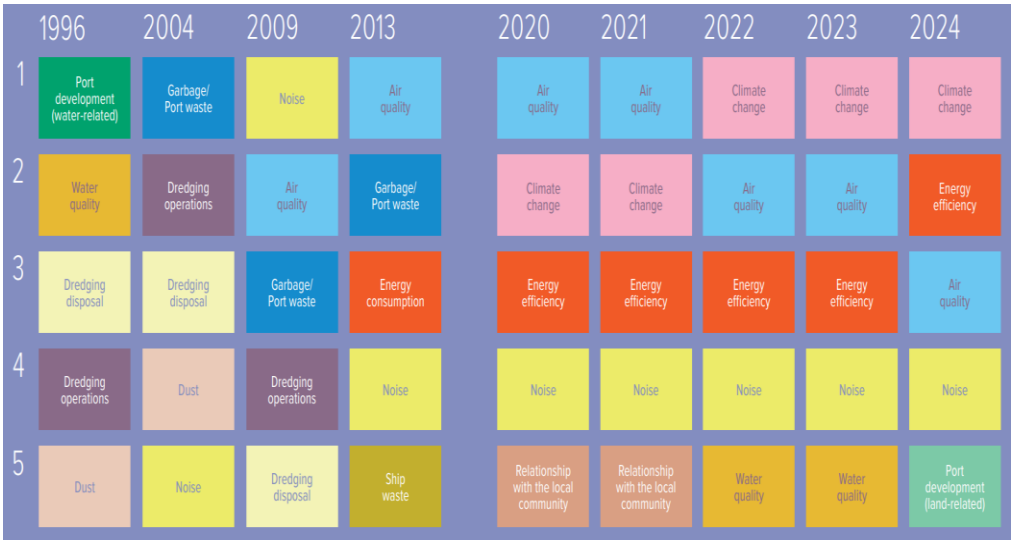
To show the environmental performance of the European ports involved in the EcoPorts Network environmental management model, 10 most important environmental management indicators have been consistently reported over time. They show the key environmental issues monitored by ports (ESPO, 2024). The group of the top six most important indicators, presented in order, i.e., according to the level of nuisance their generate, includes, climate change, energy efficiency, air quality, noise, port development (land-related) and ship waste in 2024.

Table 1 shows the trends in indicators over time, and how they have changed compared to the beginning of measurements in 1996. At the same time, the table shows that the top five indicators, which are at the same time treated as overarching priorities of ports environmental management strategy, being undoubtedly the top environmental concern of the port sector, changed only slightly in the period 2022 -- 2024 (Table 1). On the other hand, the last five priorities have seen some changes in their internal ranking since 1996 (ESPO, 2020; ESPO, 2024).

According to the data presented in the 2024 EER, what is shows in Table 1, climate change has been the top environmental priority since 2022 and it is followed by energy efficiency and air quality is the third priority of ports. Noise is the fourth priority of ports, whereas the land-related port development ranks fifth. This is nearly the same ranking as in 2019 (Nastasi *et al.,* 2020; ESPO, 2020; 2021).

As for the noise emission in the European ports, which ranks as the fourth priority for the port sector, the 2024 EER indicates that there are many potential sources of noise in the port area, which can be ambient, underwater, or a combination of these two. For instance, noise can come from machinery and cranes used for loading and unloading cargo, but also from the use of auxiliary engines from vessels in ports (Coley *et al.,* 2018; Charłampowicz and Grzelakowski, 2022; Skiba, 2013).

Table 1. *The top five priorities of the European ports sector regarded as the main indicators for the environmental monitoring programmes of the European ports in selected years between 1996 and 2024*



Source: *ESPO, 2024.*

Discussions on the negative impact of noise have gained prominence in the past years, as noise may disturb residents living near the ports, alongside wildlife in the port or in the surrounding habitats. It is clear that ports are increasingly taking action to help address the noise concerns, with almost two thirds of the surveyed ports monitoring noise levels in recent years (ESPO, 2024).

Port noise emission as an environmental concern is closely related to the relationship with the local community, which takes the ninth position among the top 10 priorities. The vast majority of the European ports are located in, or very close to, urban areas, where ports tend to be perceived by the local population as the representatives of larger maritime sector. This means that ports or some of their terminals need to address the general concerns of citizens and ensure that the port is viewed as a positive force in creating the high quality of life of the local community (Grzelakowski, 2014; Marek, 2018).

Taking this into account, it should be noted that these are very important issues, especially for urban ports such as Gdynia in Poland. In the light of steadily growing importance of environmental issues and the needs of port development, the relationship with the local community is fundamental to the port's licence to operate. However, for the majority of European ports noise is not only an environmental concern, but also a principal issue in activities aimed to safeguard the high health standards of port employees. This makes the entire port activity aimed to reduce the noise emission fundamental to the port's license to operate in urban areas.

3. Measuring, Assessing and Monitoring the Noise Emission Levels in the Port of Gdynia: Methodological Aspects

Gdynia, as a port city and the port authority, tries to minimize the adverse environmental effects of the activity of seaport, namely a universal port, handling over 29 million tons of cargo in last two years. The actions taken come down to constant monitoring of noise levels and the implementation of new solutions aimed to reduce the noise intensity.

The obligation to perform noise measurements by the port authority results from the Regulation of the Minister of Environment of 16 June 2011 and the EU directives, as well as the EEA recommendations and the application of good practice models promoted by EcoPorts Networks and ESPO (De Kluijvera, 2003; Rozporządzenia Ministra Środowiska, 2021).

Noise measurements in the port are also used to develop fact sheets, reported every five years by EEA member countries as part of the obligations, arising from the END, taking into account the latest official data regarding noise levels in the port agglomeration. Annexes 1 and 2 present the results of the periodic measurement of environmental noise levels in 2020 and 2023 during the day (Annex 1) and the night (Annex 2), caused by the production activity of the seaport in Gdynia.

The noise level measurements performed by the Port of Gdynia Authority at that time indicates that: 1/ slight exceedance of noise level was observed during the day and only in a few points in the port area, 2/ whereas at night exceedance was not observed at all. Therefore, the research results indicate that the noise associated with the seaport activity falls below the acoustic background generated by other sources of noise – in particular, traffic noise, generated mainly by road transport. It mainly refers to the area around BCT - Baltic Container Terminal Sp. z o.o (Port Gdynia, 2024).

Most of the handling operations performed in the port of Gdynia, related to noise emission, as one of the most strongly experienced nuisances for the environment, are conducted in the area of particular quays situated at a considerable distance from the areas subject to noise protection. Moreover, the Port of Gdynia Authority S.A. undertakes many activities and introduces various solutions to monitor the noise level on an ongoing basis and reduce the noise intensity, such as the *yetiSense* system, smart port management systems, or the supply of ships with electricity when ships are at berth.

The *yetiSense* system, is an innovative system, comprising networks of sensors. The networks are installed in the most sensitive areas in the port and its vicinity. The main task of the sensors is to measure not only the dust content, but also the noise intensity. If any anomaly is detected, the system immediately alerts the Port of Gdynia Authority S.A. about the exceeded permissible environment pollution

standards. Thanks to the use of advanced learning artificial intelligence algorithms, the *yetiSense* system can predict potential threats several days in advance. What is more, it can also integrate and analyse data from an unlimited number of sensors, even from other manufacturers, e.g., ARMAAG (Agency of Regional Air Quality Monitoring) (Port Gdynia – System yetisense, 2024).

Another method of fighting high noise levels involves the implementation of smart noise measurement and monitoring system in the port of Gdynia. This project perfectly fits into the activities of the Port Authority in line with the idea of "greenport" which is the reason for the functioning of EcoPorts Network and the implementation of one of the basic priorities within this activity - care for the natural environment. The facilitation of road traffic in the area around the port will also certainly reduce its adverse impact on the environment, in particular a significant reduction in noise levels (Rynekinfrastruktury.pl, 2024).

The latest solution applied in Gdynia includes the introduction of possible supply of ships with electricity when the ships are at berth. It undoubtedly exerts a very beneficial impact on the environment, mainly by reducing noise level in the port and almost completely reducing noise and vibration on the ship (Zielona gospodarka, 2023; Skiba, 2013; Marek, 2018).

In accordance with the objective of the study, regardless of noise measurements performed by the port authority, the intensity of noise in the city of Gdynia was measured in the areas where the densely populated urban zone and the port are located in close vicinity. This one-off and at the same time very detailed study was only a test. Three sites were selected as areas where the noise intensity was measured.

Figure 1 presents marked sites where measurements were performed. The border of Baltic Container Terminal (BCT) was selected as site no. 1 (zone 1). BCT is the second largest Polish maritime handing terminal, adapted to handle containerized cargo in various transport relations. With the current handling capacity of 1 million TEU, BCT is one of the largest terminals in the Baltic Sea region. It is also an efficient, well-operating terminal, ranked 90th in terms of the operational efficiency among 351 container ports/terminals in the world, covered by the World Bank survey in 2020 (WB and S&P Global, 2021 and 2023; Charłampowicz and Grzelakowski, 2022).

Measurement site no. 2 (zone 2) is located near Nasypowa street, which is located 200 meters away from the measurement site no. 1 in a direct line. Whereas the vicinity of “Walentynowicz” roundabout at the junction of Bosmańska, Nasypowa and Benisławskiego streets was selected as measurement site no. 3. Measurement site no. 3 (zone 3) is located 200 meters aways from measurement site no. 2 (Figure 1). Between measurement sites no. 1-3 there are no barriers hindering the flow of noise.

Figure 1. *Sites where noise level measurements are performed in the area where the city meets the port of Gdynia*

Source: *Own elaboration with Scribblemaps.com, 2024.*

Benetech 1356 sound intensity meter with time constant of Fast type meter turned on was used to perform the measurements. For the purpose of wind protection, the microphone had a cover on. The measuring set had a valid calibration certificate. Table 2 presents basic technical parameters of the measuring device.

Table 2. *Technical parameters of the applied noise level measuring device*

Parameter	**Scope**
1. Satisfied standards	- International electrician committee standard: IEC PUB 651 TYPE2 - US national standard: ANSI S1.4 TYPE2
2. Measurement range	- 30-130 dBA - 35-130 dBC
3. Accuracy	± 1,5 dB
4. Resolution	0,1 dB
5. Frequency	31.5Hz ~ 8.5KHz
6. Correction filters	A and C
7. Measurement modes	Fast/Slow

Source: *(Benetech-poland.pl, 2024)*

With the use of measuring device, the noise level was assessed in each of the three selected measurement sites over two days (Friday and Saturday, 28-29.06.2024) in selected short time intervals at night, during the day and in the evening.

4. Research Results and their Interpretation

As a result of the study, data was obtained regarding noise level in dB within each site by time. The data was used to calculate the values of logarithmic mean and the maximum and minimum values obtained during the conducted research, as well as

the median and mode. The following formula was used to calculate the logarithmic mean:

(2) $$L_{mean} = 10\log\left(\frac{1}{n}\sum_{i=1}^{n} 10^{0,1L_i}\right)$$

The results of the above-mentioned calculations for the first and the second day of research are presented in Table 3 and Table 4, respectively.

Table 3. *Results of calculations for research on 28.06.2024 (Friday) (data in dB)*

Measurement site	Start of measurement	End of measurement	Logarithmic mean	Max. value	Min. value	Median	Mode
Site no. 1	0:00:00	0:01:00	52.4	55.1	47,8	52.2	51.8 g
Site no. 1	4:00:00	4:01:00	54.4	63.3	47.6	52.2	50.9
Site no. 1	8:00:00	8:01:00	61.3	74.5	50.6	56.6	57.8
Site no. 1	12:00:00	12:01:00	64.8	76.8	50.4	60.2	62.2
Site no. 1	16:00:00	16:01:00	63	70.9	51.4	59.6	62.3
Site no. 1	20:00:00	20:01:00	59.3	73.2	49.3	52.7	52.2
Site no. 2	0:00:00	0:01:00	62.7	72.5	52.3	58.6	53.3
Site no. 2	4:00:00	4:01:00	59.2	68.9	50.7	54.8	53.6
Site no. 2	8:00:00	8:01:00	68.4	75.5	56.9	65.6	60.3
Site no. 2	12:00:00	12:01:00	70	75.8	55.2	68.7	64.5
Site no. 2	16:00:00	16:01:00	70.3	75.6	58.7	69.5	72.5
Site no. 2	20:00:00	20:01:00	64.2	70.9	52.1	62.1	61.3
Site no. 3	0:00:00	0:01:00	58.7	68.8	49.6	55.4	51.1
Site no. 3	4:00:00	4:01:00	57.3	65.2	50.2	53.6	54.6
Site no. 3	8:00:00	8:01:00	64.7	70.3	54.3	62.2	59.6
Site no. 3	12:00:00	12:01:00	65.4	73.5	52.0	63.5	62.2
Site no. 3	16:00:00	16:01:00	65.7	71.5	54.7	62.5	62.5
Site no. 3	20:00:00	20:01:00	60.9	65.4	53.4	60.7	60.8

Source: *Own elaboration.*

Table 4. *Results of calculations for research on 29.06.2024 (Saturday) (data in dB)*

Measurement site	Start of measurement	End of measurement	Logarithmic mean	Max. value	Min. value	Median	Mode
Site no. 1	0:00:00	0:01:00	55.9	66.8	47.5	52.6	53.6
Site no. 1	4:00:00	4:01:00	54.2	63.0	47.0	52.6	51.2
Site no. 1	8:00:00	8:01:00	58.6	66.6	48.2	55.7	54.2
Site no. 1	12:00:00	12:01:00	62.3	70.5	50.0	59.9	57.8
Site no. 1	16:00:00	16:01:00	63.4	71.2	52.3	60.3	62.3
Site no. 1	20:00:00	20:01:00	56.6	68.2	46.2	53.6	53.6

Site no. 2	0:00:00	0:01:00	60.6	75.6	47.6	55.6	56.3
Site no. 2	4:00:00	4:01:00	59.6	70.5	48.5	54.7	53.6
Site no. 2	8:00:00	8:01:00	68	76.8	52.3	65.1	53.6
Site no. 2	12:00:00	12:01:00	67.9	76.7	48.7	65.8	64.8
Site no. 2	16:00:00	16:01:00	68.2	74.8	50.6	65.9	66.8
Site no. 2	20:00:00	20:01:00	62.6	72.3	52.8	59.8	57.8
Site no. 3	0:00:00	0:01:00	57.6	67.8	47.8	53.7	52.3
Site no. 3	4:00:00	4:01:00	55.9	63.1	49.0	51.9	51.9
Site no. 3	8:00:00	8:01:00	62.7	68.8	52.5	60.2	57.7
Site no. 3	12:00:00	12:01:00	63.6	71.1	50.3	61.5	60.2
Site no. 3	16:00:00	16:01:00	63.3	69.2	51.5	60.7	60.5
Site no. 3	20:00:00	20:01:00	59.1	63.9	51.1	58.4	57.1

Source: *Own elaboration.*

Calculation results presented in Table 3 and 4 were presented in a graphic form in Figures 2–5. Figures 2 and 3 presented the 24-hour distribution of noise levels in the form of logarithmic mean, for research conducted on a workday and on a weekend day, respectively.

Figure 2. *Daily distribution of logarithmic mean – logarithmic mean –on a workday*

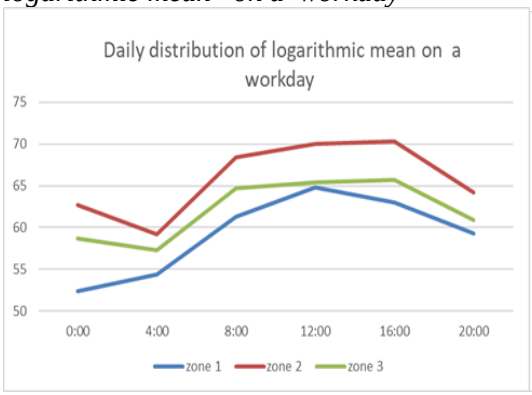
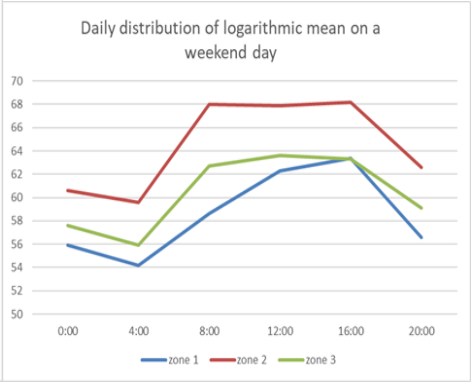


Figure 3*. Daily distribution of on a weekend day;*



Source: *Own elaboration.*

The distributions presented in Figure 2 and Figure 3 of the noise level logarithmic mean, for measurements on a workday and then on a weekend day prove that the noise highest level within 24 hours was observed in site no. 2.

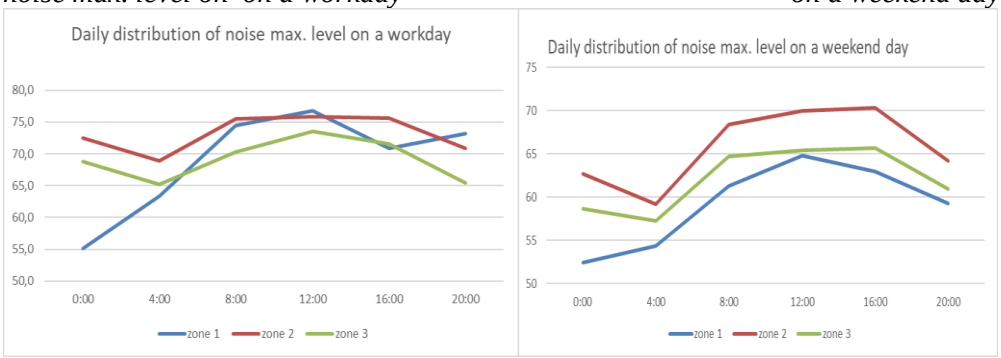
The subsequent place in terms of the logarithmic mean is assigned to site no. 3, while the lowest value is recorded in site no. 1, i.e., in the immediate vicinity of BCT. The indicated hierarchy occurs practically throughout the entire measurement day, both for tests performed on a workday and on a weekend day.

The noise highest levels are recorded between 8.00 and 20.00. However, outside this interval, the noise level drops significantly. It results mainly from the reduced activity of road transport which significantly affects the results recorded in site no. 2 and no. 3, and the seaport operational activity which strongly affects the results of noise measurements from site no. 1.

Moreover, while comparing the measurement days, it is possible to notice that the results of noise levels between 8.00 and 20.00 are a few decibels higher on a workday than on a weekend day. During the night hours, the level of noise shows similar intensity, regardless of whether it is a workday or a weekend day. Figure 4 and 5 present daily distributions of the noise max. level for workday and weekend day measurements, respectively.

Figure 4. *Daily distribution of noise max. level noise max. level on on a workday*

Figure 5*. Daily distribution of on a weekend day*



Source: *Own elaboration.*

Figure 4 shows that the noise highest intensity on a workday during 24 hours is recorded in the vicinity of measurement site no. 1 at 12:00. It amounted to 76.8 dB. Therefore, it quite significantly exceeds the standards determined based on the END and adopted by EEA within this period of time. It probably results from the high intensity of handling operations conducted in the seaport, and in particular at the BCT terminal, during the workday. Outside these hours, the noise maximum intensity is recorded near the measurement site no. 2.

The distribution of noise levels during the weekend day shows that the noise highest intensity within 24 hours is recorded near the measurement site no. 2 at 08:00– it amounted to as much as 74.5 dB (Figure 5). However, at 4:00 p.m., in all measurement sites we can observe a decrease in the noise maximum level because of the reduced road traffic and a decrease in the port handling operations. Yet, while comparing the maximum daily values obtained on a workday with a weekend day, no fundamental differences can be observed. It arises from the nature and mode of seaport operations as well as the distribution of the intensity of road and rail traffic to and from the port.

5. The Impact of Gdynia Port Container Noise Emission on Local Community: Discussion

The study aimed not only to make a noise level test assessment in the port of Gdynia at the BCT container terminal located in close vicinity of a housing estate but also to compare it with the END indicators for noise pollution set at the following levels: 1/ 55dB for *Lden: day-evening-night*, and 2/ 50dB for *Lnight: night*. The study (stage 1) also aimed to determine the extent and degree of port noise affecting the inhabitants of the nearest housing estate.

Attaining such a defined research goal and the requirement to verify the accepted hypotheses required a survey conducted using a questionnaire. The survey was to enable getting the opinions of the residents of Nadmorskie Tarasy housing estate at ul. Nasypowa located near BCT in Gdynia on the noise intensity levels and sources of noise as well as assessing the noise impact on residents.

This housing estate is located near the measurement site no. 2, where noise intensity tests were performed using a decibel meter. The location enables to provide a reliable assessment of noise level coming from both port operations and high activity of road vehicles passing in the port vicinity. The housing estate is currently inhabited by about 600 people. Out of the 250 questionnaires sent, we obtained 154 correctly completed questionnaires.

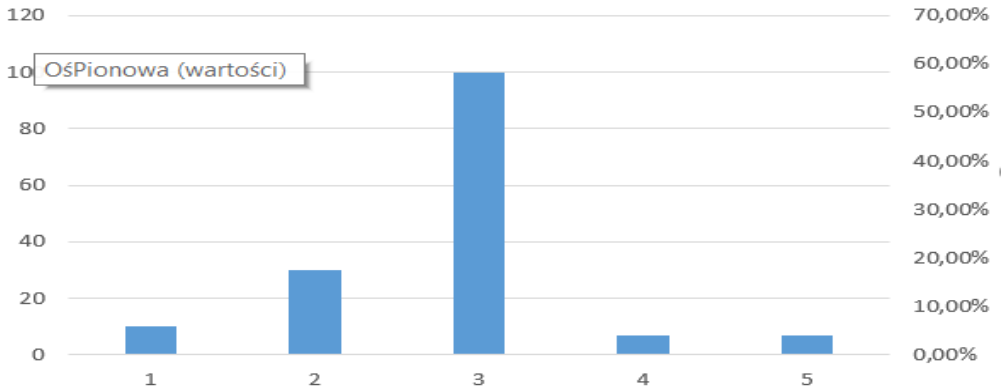
The questionnaire contained six main questions. The first referred to the period of residence at Nadmorskie Tarasy housing estate. Since the first residents moved in the housing estate about 2 years ago, the respondents' average length of residence amounted to one year.

Question number two referred to the residents' assessment of noise intensity in the housing estate. The responses were presented in Figure 6. The diagram shows the scale of noise intensity in the housing estate as per the residents' opinion. In order to assess the above-mentioned phenomenon, the scale from 1 to 5 was adopted, where 1 meant - very quiet, 3 - moderate, and 5 - very loud. The majority of residents (60%) had a neutral attitude to the noise level. Only under 5% of residents believes that it is loud at the housing estate.

Another issue referred to indicating the source of noise. The responses indicate that the main source of noise refers to the port operations – 84.3% of respondents. Only 15.7% of respondents indicated road traffic as the main source of noise.

In the responses to the fifth question, the residents were to indicate on what days the noise intensity was more noticeable: weekend days or workdays. The results indicate that for 54.9% there is no difference in terms of noise intensity throughout the entire week. More than 27% indicated that the noise level on a workday is higher than on a weekend day; the others indicated the weekend day.

Figure 6. *Assessment of noise intensity, provided by the residents of Nadmorskie Tarasy housing estate Vertical axis (values).*

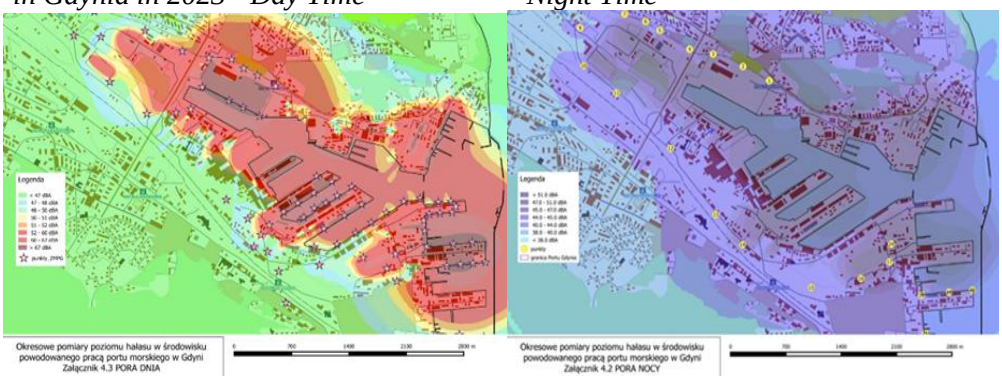


Source: *Own elaboration.*

The final question referred to the time of day when residents found the noise level to be the most burdensome. According to 72.5% of respondents, noise intensity is most troublesome at night. The reason for this assessment is explained in the two following Figures 7 and 8.

Figure 7. *Noise levels generated by the operations in the port -in Gdynia in 2023 - Day Time*

Figure 8. *Noise levels generated by the operations in the port in Gdynia in 2023 Night Time*



Source: *Port Gdynia, 2023.*

Based on the noise level results from the measuring device, the following conclusions can be drawn:

- When analysing the average daily values of noise level, the highest values are recorded at measurement site no. 2, then in site no. 3, and the lowest average values are recorded at the border of the Baltic Container Terminal (site no. 1). The same hierarchy was applied during measurements performed on a workday and on a weekend day. By comparing the two

measurement days, it was also observed that at the weekend during the day lower measurement values were recorded than in the corresponding part of the day on a workday;

- Measurements of noise max. values for the workday showed that the highest measurement was observed at site no. 1, at the BCT border. This value was reached at 12.00. In the remaining hours, during 24 hours, the noise highest values were recorded at site no. 2. In turn, the measurement of max. values on a weekend day indicated that site no. 2 was the place where the highest values were recorded. Such situation occurred during the entire measurement day. The max. values on a weekend day at site no. 1 and no. 3 indicated relatively similar results during the entire daily distribution.

However, the results obtained with the use of the measuring device do not fully coincide with the respondents' assessments indicated in the survey research. The respondents, despite the fact that most of them do not perceive noise in their area of residence (near site no. 2) as a factor adversely affecting the comfort of their lives, take a completely different approach to indicating the main source of noise in their place of residence.

Almost 85% of respondents indicated the port as the main source of noise, where the results from the measuring device prove otherwise. Discrepancies were also observed in indicating at which time of day the noise level was the highest. The decibel meter tests clearly indicated that significantly higher noise values were recorded during the day than at night, whereas more than 72% of respondents indicated that during the night the noise level reached the highest values.

6. Final Conclusions and Recommendations

The conducted research focused on issues related to noise as one of the basic types of environmental nuisance, generating significant external costs, mainly resulting from the negative social and economic effects. The subject of study included the analysis of road traffic and noise intensity that occurs at the junction of the city and the seaport.

The research was conducted in the city port of Gdynia, and it was divided into two stages. In the first stage, noise levels were measured at three selected locations, at the border of the port and in close vicinity of these borders. The research was carried out for two measurement days - on the workday and on the weekend day.

The second stage of research included survey research. It aimed to indicate to what extent the obtained noise measurement results determined by the measuring device coincide with the noise level assessment of residents of housing estate located in the vicinity of the port.

Based on the research results obtained and conclusions drawn from the conducted case study, the following recommendations can be presented:

- In view of the growing need to apply sustainability standards and implement smart environmental management methods corresponding with EU's Sustainable and Smart Mobility Strategy, seaport authority and port terminals should underline these issues more strongly than before in their environmental protection strategies as well as CSR strategies and ESG reporting, consulting them with port stakeholders.

- Limiting the nuisance caused by port operations must be associated not only with the need to carry out green and smart investments, implementing at the same time innovative technological and organizational projects aimed, among others, to reduce noise level in the port, but also with full and reliable information provided to the residents of the port city. This in turn is related to the requirement to create special cooperation platforms or discussion forums organized by port stakeholders council (Grzelakowski, 2014).

- Port and port city authorities interested in developing sustainable mobility and smart cities, in order to improve the residents' quality of life and increase the comfort of working conditions, should cooperate more closely than before in developing and fulfilling the objectives of environmental management strategies, spatial planning and spatial development of areas around ports as well as crisis management strategies.

The suggestions and postulates indicated in the recommendations regarding the reduction of noise generated by business activities within the port area, perceived in terms of its impact on the comfort and quality of life of port city residents, should contribute to the development of partnership relations between the seaport /port terminal – residents – port city authorities.

The synergy effect to be expected in this regard in the near future depends, to a large extent, on the intensity and quality of cooperation in this three-party arrangement.

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