

UNIQUE AMBISONIC SOUNDS OF THE OLDEST FOREST IN EUROPE AND THE PROBLEM OF SILENCE RECORDING

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ABSTRACT

Constant climate and environmental changes, as well as concern about the future generations, oblige us to preserve, or at least, to record the current state, along with the natural soundscape. There are several techniques for soundfield recording available; however, for an accurate and versatile archiving and playback, careful selection must be provided. Because of the influence of the anthropogenic sounds which distribute over long distances, preservation of the pristine natural soundscape is very difficult. Therefore, there are few places in Europe to find natural environment, along with a unique soundscape, unspoilt. Undoubtedly, one of the places is the Białowieża Forest, the oldest forest in Europe.

Many exceptional species of animals and plants are present there. Apart from the unique nature sounds, you can 'hear' the real and natural silence now and then. The article presents the process of ambisonic recordings and the measurement of sound pressure level. The data was gathered in the places of strict wildlife conservation over the course of one year. The article raises the issue of recording, as well as the measurement of very soft sounds in terms of their ambisonic playback.

INTRODUCTION

There are few places in Europe to find natural environment, along with a unique soundscape, unspoilt. Undoubtedly, one of the places is the Białowieża Forest, the oldest forest in Europe. Many exceptional species of animals and plants are present there. Apart from the unique nature sounds, you can 'hear' the real and natural silence now and then. The soundscapes are associated with both social functions and time-spatial changes, or the places of residence. Social scientists, particularly anthropologists, emphasize the variety and forms of spatial arrangement of sounds and effects of soundscapes. The development of the area of studies on soundscapes indicates the possibility of creating a multi-sensory anthropology and sociology. The term 'soundscape' is well defined [1,2,3,4]. At the time being, wide-ranged research concerning its analysis and preservation is being carried out. The term 'natural soundscape' is, according to [5], an 'inherent acoustical environment of an area without the presence of human-caused sound'. Nowadays, almost every place of human habitation is surrounded by din and noise most of the time. With the development of industry the environmental noise is obviously more perceptible. The most significant and common noise source is the road traffic. Additionally, the typical human soundscapes includes also the noise generated by industry, aircraft, wind turbines, railways, craft services, farms, playgrounds, municipal facilities, renovations, and household appliances.

Because of all the things mentioned, quietness seems to be unique these days. However, it has not been clearly defined. From the audiologic point of view, quietness is a signal, amplitude of which is lower than the auditory threshold (for every frequency). But we can differentiate between the acoustic concept of measurable quietness from audible quietness, which is a subjective psychological notion. Thus, if there are always some sounds in the air, it is interesting to find, what is the correlation between the perceptible values and the measurable ones and make an attempt to determine the threshold of quietness not in the audiometric sense as an ability to hear sounds, but as a definite, objective description of the state of the acoustic field.

In 2013, the Mechanics and Vibroacoustics Department of the AGH-UST in Kraków started a series of ambisonic recordings in the Niepołomice Forest (a National Park located 50km from Kraków) [6]. Because of the neighbouring motorway, railway track and households, anthropogenic noise was audible even in the outermost corners of the forest. That is why, the recordings along with the measurement of the sound level, were made in the Białowieża Forest – the oldest and best preserved forest in Europe. It has been noticed from the very beginning that in some places of the forest there is no sound at all, for a very long time. In details, there are no anthropogenic sounds. Subsequently, it has been decided that a record as accurate as possible has to be made to save the unique circumstances. The aim was to capture the uniqueness of the place and its atmosphere in order to make further research of the soundscape, as well as to create a point of reference for other, similar places; also, in case of any future needs.

UNESCO HERITAGE LIST AND BIALOWIEZA FOREST

A UNESCO World Heritage List [7] is list with sites (such as a building, city, complex, desert, forest, island, lake, monument, or mountain) that have been nominated for the United Nations Educational, Scientific and Cultural Organization's International World Heritage program. The program aims to catalogue and preserve sites of outstanding importance, either cultural or natural, to the common heritage of humankind. There are fourteen objects in Poland inscribed under the UNESCO's World Heritage List and for two years in the Department of Mechanics and Vibroacoustics AGH-UST there are conducted extensive research related to acoustics properties of Unesco objects.

Searching for a soundscape where quietness reigns is in accord with the definition of the soundscape ecology and is a special case of the acoustic environment of the contemporary man. The authors have carried out their investigations in the area of the Białowieża National Park.

Białowieża Forest has been designated a UNESCO World Heritage Site, a UNESCO Biosphere Reserve, and an EU Natura 2000 Special Area of Conservation. The oldest forest in Europe preserved in its virtually natural condition. The recording and measurements were performed at selected characteristic locations at which the level of the acoustic background was registered at favorable weather conditions. In a spot most remote from human settlements it is a location in the strict nature reserve where it is possible to see all indigenous animals and birds subject to strict species protection in Poland. Also in a spot located close to a road. Since it serves as an animal feeding point, it is frequented visited by wisents (European bison) in the winter. And in a location on the border between the natural environment and human settlements. It is a meadow in which one can find several species of animals and birds protected in Poland. At the same time, the closest human dwellings are just 0.5 km away from it. The Białowieża National Park is situated in the north-east part of Poland, in podlaskie voivodeship (Figure 1). Its beginnings can be traced back to 1921, when the "Reserve" forestry was created at the place currently occupied by the Park.



Figure 1: Location of the Białowieża Forest

The Białowieża Forest covers the area of 5725,75 ha and is under strict protection. Białowieża Forest is the last natural forest at the European Lowland Area, having the primaeval character, identical with the one which covered the area of deciduous and coniferous forests years ago. The characteristic feature of the park is its biological diversity. The Białowieża Forest comprises about 809 vascular plants species, over 3 thousand cryptogams and fungi species, almost 200 moss species and 283 lichen species. There have been more than 8 thousand invertebrates species, approximately 120 species of breeding birds and 52 mammal species. Old, primaeval forest stands in Białowieża National Park are characterized by large amounts of deadwood at the various stage of disintegration, and by the presence of typical natural forest species. Apart from Białowieża Forest, many of the aforementioned species can be identified only in few places worldwide. European bison – the biggest European land mammal [8]. Photo in Figure 2 shows mobile recording station at the gate of the Białowieża Forest.



Figure 2: Mobile recording station [9] at the Białowieża Forest

AMBISONIC RECORDINGS

Ambisonic recordings of natural soundscape at the Białowieża Forest were carried out from August 2014 to June 2015. The recordings and measurements were made during every of the four seasons of the year. B-format material of over 160 GB was recorded, which constitutes about 114 hours of recordings with the sampling frequency of 44 100 Hz and the 24 bits resolution. Recordings were conducted using first order ambisonic microphone SoundField ST350 with AD/DA converters and preamplifiers integrated in RME Fireface 800 device.

Mobile recording station (Figure 2), thanks to solar power and batteries, provides the possibility of long-term recording, without raising the level of background noise. It is equipped with a hard-disk system for storing recordings, a set of analog to digital converters, and a system for monitoring the recorded signal. Size and functionality of the vehicle also allow the installation of racks and microphone stands to provide the required functionality and weather resistance.

Natural sounds, which are present during the four of the seasons of the year, were recorded. The recordings start with an early spring morning which then turns into summer day and night. Then, typical sounds present during an autumn evening were saved, as well as sounds of a winter night and the beginning of a winter day. The choice was made because of the frequency of occurrence of such typical sounds during these times. A, so called, 'typical ambient' for the times of the day mentioned was recorded. Also, plenty of unique sounds connected with many kinds of birds, insects and mammals were recorded. Both typical and unique types of birds: jay, nutchach, great tit, robin, great spotted woodpecker, blackbird, black woodpecker, firecrest, tawny owl. A roebuck in the early morning and a fox at night emitting warning signs together with a wisent looking for food at night. At the autumn there were the rut from different distances, in the evening recorded together with crickets and flying insects.

NATURAL QUIETNESS?

The studies of quietness were performed at three selected characteristic locations at which the level of the acoustic background was registered at favorable weather conditions: Dziejzinka is a spot most remote from human settlements it is a location in the strict nature reserve where it is possible to see all indigenous animals and birds subject to strict species protection in Poland. Ostoja is a spot located close to a road. Since it serves as an animal feeding point, it is frequented visited by wisents (European bisons) in the winter. Gruszki is a location on the border between the natural environment and human settlements. It is a meadow in which one can find several species of animals and birds protected in Poland. At the same time, the closest human dwellings are just 0.5 km away from it.

For many of the periods of time recorded, very low levels of sound occurred. The team which was carrying out the recordings, named it to be a complete silence. Along with the recordings, measurements of the sound level were made. The analysis of the results provoked thought whether the recordings were correct. The reason for that was that the recording and the metrological apparatus' sensitivities were ill-matched. It turned out that the periods of silence occurring naturally, are below the measurement range applied, and, much less below the noise of the ambisonic microphone itself. Within additional, sound analyzer SVAN 959 with microphone 40AE by G.R.A.S. and a microphone preamplifier SV12L was subjected to examination in the anechoic chamber. The device has two measurement ranges (LOW and HIGH) and two operating modes (sound meter and sound analyzer). In the instruction manual of the device, the manufacturer declares the measuring range of the values of sound starting from 12 dBA but does not define the range of measurement of 1/3-octave bands. Due to very low values of acoustic pressure in particular bands of 1/3-octave frequencies, it proved to be necessary to describe the results of the measurements of the acoustic pressure levels with respect to the measurement range of the used wave analyzer. Measurements of electrical and acoustic noise of the device were executed for a typical measuring set configuration (microphone, preamplifier, extension cord, meter) with the compensation filters and calibration corrections appropriate for measurements in the free field. In the examination of the electrical noise of the device, the microphone was replaced by a 18 pF capacitor representing impedance of a microphone, while the acoustic noise was measured in the anechoic chamber. The

measurements were executed due to the difficulties occurring during the attempt to record sounds with low level of acoustic pressure. Analyzing the results of examination of the noises produced by the measuring system working as a sound level meter (measured at the AGH University of Science and Technology and declared by the manufacturer) we can state that the values of the measured sound levels A in the Białowieża Forest are above the levels of noise produced by the measuring device (Figure 3).

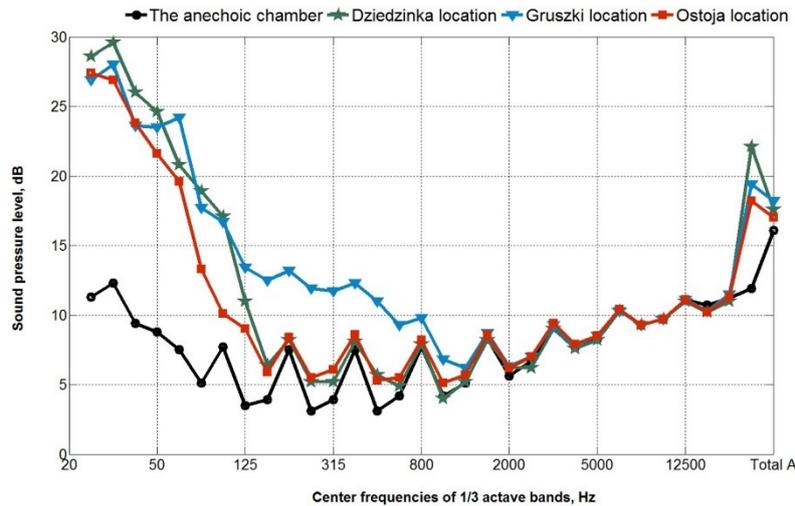


Figure 3 Comparison of results of spectrum analysis of the acoustic pressure measurements in 1/3-octave bands taken in the Białowieża Forest (at three different locations) in quietness and in the anechoic chamber for 15-minute time intervals.

On the other hand, the analysis of the self-generated noise produced by the device working as a sound analyzer in 1/3-octave bands shows that in the range of selected frequency bands, this sound analyzer is not able to measure as low values of acoustic pressure as those occurring in the Forest.

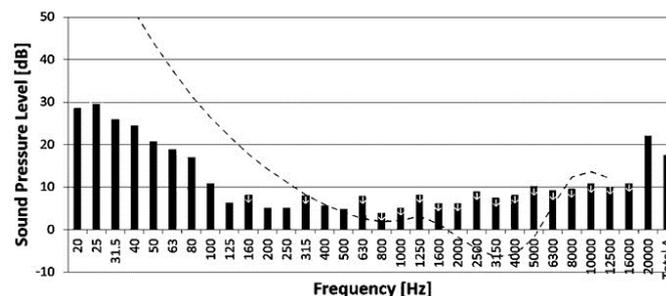


Figure 4 Spectrum of the sound pressure level in 1/3 octave bands recorded at night at Białowieża Forest.

The spectrum of the sound pressure level in 1/3-octave bands is shown in Figure 4. Measurement was taken for 15-minute time interval. Very low value of A-weighted sound level was measured (17.0 dBA). It is the lowest level recorded throughout the night but additional statistical distributions of levels shown, that this range of values has last for more than 90 percent of nighttime [10]. This kind of levels are rarely occurring in other areas, in the surround of noises coming from roads, industrial objects, housing estates, or agricultural activity in the acoustic background.

In the diagram in Figure 4, apart from the measured signal, the absolute threshold of hearing (0-phon according to [11]) was marked as well as the frequency bands in which the values of the signal amplitudes were below the measuring system's own noises. The absolute threshold of hearing was marked with a dashed line while the bands for which the signal could reach values lower than the recorded ones, due to the limitations of the lower measurement range of the equipment, were marked by arrows on particular bars. The presented results indicate that, the

measured values of the levels of sounds within the measuring range of the set-up were below the human threshold of hearing. For the bands of medium and high frequencies, to which human ear is most sensitive, the used measuring system is characterized by its own noises far above the threshold of hearing. The physical value of the acoustic pressure for the indicated range of frequencies is very low but its precise value is unknown. We might guess that it is the values of the acoustic pressure that significantly influence the perception of silence because in the subjective experience of the people taking the measurements, their experience was highly different from the quietness that is perceived in the laboratory conditions of an anechoic chamber. The self-noise of the ambisonic microphone used, declared by the producer [12], is much higher than in case of the measurement microphones. That is why, all signals of too low a level, are masked by noise. Even after slight intensification of the recording system, they are becoming awkward and are not to be trusted.

SUMMARY

Life in a noise, especially in huge urban agglomerations, has a harmful effect on human health and mental condition. Quietness understood as absence of undesired sounds or sounds in general may be vexing and worrisome or, just the opposite, evoke the feeling of comfort. This aspect of quietness may be considered an important component of the quality of life and is connected with human biological and mental health [13]. This phenomenon must be perceived in two aspects: acoustical and psychological. In quietness, a human being relaxes, takes a rest, calms nerves, and at the same time regenerates the hair cells in the hearing organ, so after coming back to the world hustle, he/she is able to function in this acoustically aggressive environment. Having reached the oldest forest in Europe, the Białowieża National Park, the authors recorded silence generated by the nature in favorable weather at night. Answering the research question concerning quietness present in nature posed above in the Introduction, they recorded the state of acoustic background at the level of 17 dB. In the Białowieża National Park, this silence has also other aspects, psychophysical conditions included the sense of space, perception of beauty, etc. Considering silence from the psychological point of view we should mention that the response to noise and to the absence of sounds is connected not only with the general nervous sensitivity, age, and habits, but also with the health condition and the level of exhaustion. Therefore, determining the limit value of sound pressure above or below which we can speak of quietness, depends on too many variables connected with perception of an individual person. Additionally, in order to measure such low levels of sound pressure and to analyze the spectra of the measured sounds, it is necessary to have the equipment (sound analyzers) with well-described ranges of the measured sounds and well-defined internal noises for different measuring configurations.

Because of the changing climate and increasing anthropic activities, archiving of the soundscape is essential. The recordings and measurements made in a place as unique as the Białowieża Forest, which is a member of the UNESCO World Heritage List, come as important, but not sufficient activities. Further series of similar recordings and measurements are needed to be done in places equally untamed and abundant, such as, for example, the Carpathian Mountains, the Alps or other places in Europe where unique and well-conserved ecosystems still exist. The recordings, measurements and attempts to play the records, showed that there is a problem with the apparatus' wrong range as to the measurements, as well as too much self-noise occurring. Detailed measurements of the electroacoustic track were made and the conclusions were that it is necessary to use an additional, low self-noise microphone, as well as it is essential to process and play sounds, which are on the verge of the hearing threshold, separately. The optimal approach would be to construct a low-noise ambisonic microphone. The other solution is using dynamic processors or applying pressure signal only and to perform additional ambisonic panning with it.

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