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CHARACTERISTICS OF ANNUAL EXPOSURE TO NOISE AMONG PRIVATE FARMERS ON FAMILY FARMS OF MIXED-PRODUCTION PROFILE

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Abstract: The objective of the study was the recognition and evaluation of annual exposure to noise among private farmers on farms engaged in mixed (plant-animal) production. The study covered 16 family farms using land of the size 13-30 ha (20.4 ha on average). The farms were equipped with agricultural tractors (2.4 tractors on average), selected workshop machinery, saws for logging and machines for the production of fodder. The following basic parameters were applied for the hygienic evaluation of noise: total monthly exposure and mean equivalent daily exposure expressed in Pa^2 h. The study indicated that the highest values for total monthly exposure to noise were observed in 5 months, i.e. September, October, August, November and April. High total exposure values obtained in the summer-autumn months (August-November) are associated with the performance of such work activities as: harvesting of cereals and root plants, and cultivation of soil (characterised by the emission of sounds of high levels), with prolonged exposure to this factor and a large number of workdays in these months. In April, however, the occurrence of high total exposure values was due to intensive field activities (ploughing, harrowing, sowing), and prolonged exposure to this factor. In the seasons of the year analysed, high equivalent exposure values were observed within the range: 5.53-6.61 Pa^2 h. Mean value for this parameter for the whole year reached the value of 4.27 Pa^2 h (standard exceeded 4.3 times). This value is equivalent to a mean exposure level equal to 91.3 dB. The results of studies of annual exposure to noise obtained by some other authors are close to the data presented in this report, and confirm that the degree of noise load clearly depends on the type of agricultural production and type of machines applied.

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Key words: annual exposure to noise, monthly exposure, equivalent daily exposure, mixed production profile.

INTRODUCTION

Studies conducted to-date concerning noise occurring on private farms [5, 6] have shown high variations in the registered noise levels, with a considerable variability of the duration of exposure to this hazardous factor. This is conditioned primarily by farmers using tractors of various types (Polish and foreign made), equipped with engines of various power (low, medium or high), as well as by the emission of changing levels of noise, according to the type of field or transport work activities performed (this is directly associated with engine load value). In general, the level of noise is shaped according to the production profile and the size of cultivated land.

An evaluation of annual exposure to noise among private farmers who run farms of specialised directions of production is a new problem which has not been comprehensively undertaken, neither in Poland nor abroad; this article, therefore, is an original contribution. In order to recognize and evaluate an annual exposure to

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noise among private farmers on farms carrying out mixed production (plant-animal) studies were undertaken within the statutory research problem [8]. This was the objective of the presented study. The majority of Polish farms producing for retail are of mixed-production profile.

MATERIALS AND METHODS

The studies covered 16 farms located in the area of 2 communes in the Lublin Region, using arable land of the size 13-30 ha (20.4 ha on average). On the farms in the study, a total number of 38 agricultural tractors of various power were used (Polish, Czech and Belarusian manufacture), among which the greatest number were medium-power tractors (20 tractors, mainly of the C-360 type), and low-power tractors (12 tractors, mainly C-330 type), followed by Czech made tractors (5 tractors, 'Zetor' type), and 1 high-power tractor of the type MTZ-82 (Belarusian manufacture).

The farms in the study were equipped with a basic set of agricultural machinery coupled with a tractor, some self-propelled machines (primarily combine harvesters - 7), selected workshop machinery for the repair of agricultural machines and equipment (e.g. angular grinders, bench grinders, drill, welders, etc.), as well as machinery for logging (circular and/or chain saws) and machinery for the production of fodder (radial plate grinding mills, grinding mills of the "Bąk" type, grain crushers and fodder mixing machines).

The selected farms carried out mixed production (plant and animal). With respect to plant production the farms were engaged in the growing of cereals, sugar beets, vegetables (carrot, cauliflower, cabbage, parsnip, red beetroots), sweet corn, amaranthus and production of green fodder and hay.

Animal production covered dairy cattle breeding (9-44 cows per farm, 18 cows on average) or swine breeding – 12-80 swine annually (38 animals on average).

For the production of fodder for breeding animals, mainly own raw materials were applied, based on cereals, green fodder, sweet corn, hay and beet pulp, carrot and beetroot leaves.

The scope of studies covered:

- keeping time-schedule records of agricultural activities performed by farmers on their own farms, during which there occurred exposure to noise (these measurements were carried out by farmers under the supervision and control of the research team from the Institute);
- dosimetric measurements of noise emitted by agricultural machinery and equipment while performing selected agricultural activities.

Time-schedule measurements were performed throughout the whole year (2004). Dosimetric measurements were carried out with the use of the following noise dosimeters: Bruel-Kjaer Type 4436, Sonopan Type D-20 and Robotron Type 00080. The basic acoustic parameter characterizing risk was the so-called 'exposure to noise' [$E_{A,T}$] expressed in $Pa^2 \cdot h$, according to the Polish standard [4].

The following values were determined in order to evaluate exposure to noise: total monthly exposure to noise and mean equivalent daily exposure (referring to legally accepted workdays in a month). The mean equivalent daily exposure (for an individual month) is the value obtained from the ratio between the total monthly exposure to the number of days legally established as workdays in an individual month.

The results of the studies were statistically analysed by means of computer statistical package SPSS/PC [10]. Analysis covered such statistical parameters as: normality of the distribution (skewness, kurtosis, Kołmogorow-Smirnow test), mean value (arithmetic), the degree of data dispersion (range, standard deviation, confidence intervals). In order to define the degree of variation of the results of the studies obtained, one way analysis of variance was conducted by means of F test. Leven test was applied to investigate the homogeneity of variance. In order to evaluate differences occurring between the obtained mean values referring to individual months of the year, Duncan test of multiple comparisons was used. The value of $p \geq 0.05$ was adopted as the evaluation criterion of statistical significance of the parameters analysed (Kołmogorow-Smirnow test, F test, Leven and Duncan tests).

RESULTS

Table 1 presents the basic statistical data concerning the total exposure to noise in individual months of the year for the farms of mixed-production profile. The values obtained showed the occurrence of great variability of the data in 2 months: December and March, due to the high values of standard deviations (exceeding mean values), high values of kurtosis coefficients (k = 1.93 - 6.69), skewness coefficients (α = 1.64 - 2.38), and a wide range of the values measured (2.0–441.9 $Pa^2 \cdot h$). Despite such a great dispersion of values, data distributions in these months remain within the range of normal distribution (Kołmogorow-Smirnow test; p = 0.23 - 0.25). Decidedly the best data distribution was noted in the following months: February (p = 0.94), May (0.83) and September (0.76).

Calculated confidence intervals determining most frequently occurring mean values of total monthly exposure to noise had the smallest widths (for the level of confidence 95% and 2-sided Student test, 2.5% of the level of significance on each side) in 6 months of the year: February, April, June, August, September and October (the ratio between the upper limits of confidence intervals to mean values achieved: 1.33–1.42; which in the logarithmic scale of values is equivalent to 1.2–1.5 dB). The results obtained in the above-mentioned months should be classified as relatively precise. During the remaining months of the year (January, March, May, July, November and December) the width of the confidence intervals was greater, while the upper confidence limits

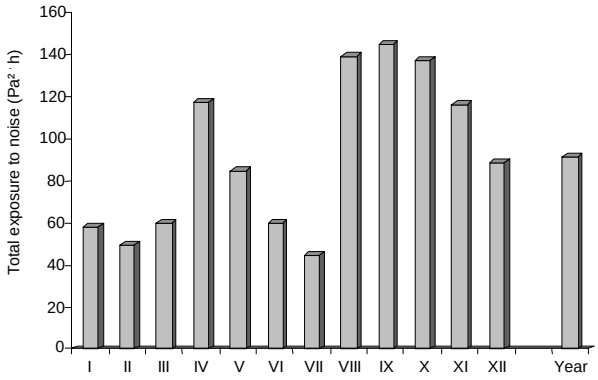

Figure 1. Mean values of total exposure to noise in individual months.

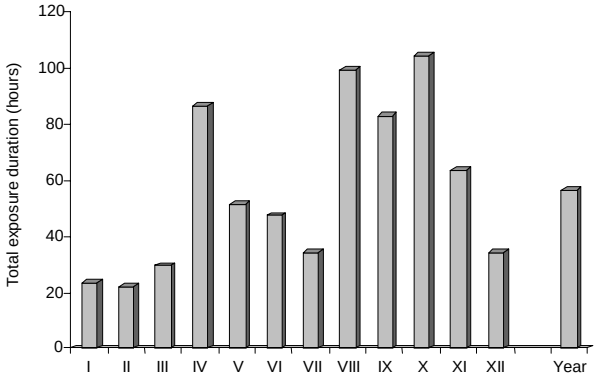

Figure 2. Mean values of total exposure time in individual months.

achieved the data within the range from 1.44 x_{mean} (1.6 dB) in November to 1.67 x_{mean} (2.2 dB) in December. The mean values in these months were already characterized by some dispersion; however, they still remained within the range of moderate accuracy value.

The analysis of variance showed that the level of variation of results obtained for total exposure to noise in individual months was high (F test = 3.577, p = 0.0001). The Level test, in turn, indicated that the variance was non-homogenous (S = 2.306; p = 0.012). Studies of the significance of differences between mean values for total exposure, (between the pairs) in individual months by means of Duncan test, showed significant differences ($p < 0.05$) between July and February and November, April, August, October and September; and between January, June and March and August, October and September. These data clearly confirm the occurrence of variation in total values for exposure to noise according to individual months.

The analysis of mean values (arithmetic) in individual months showed that the highest values occurred in the following 5 months of the year (Fig. 1): September (145.4 $Pa^2 \cdot h$), October (137.8), August (139.3), November (116.2) and April (117.2).

The data concerning total exposure to noise in the summer-autumn months (August-November) resulted from the performance of intensive transport and field activities, such as: harvesting of cereals and root plants and soil cultivation. Noise of a high level is emitted while performing these work activities. Such high values for the total exposure to noise in these months resulted also from a long time of exposure to this factor (Fig. 2) – (mean monthly exposure time: 63–105 h), relatively often expressed by prolonged working time (Fig. 3) in individual work days (maximum up to 9.4 h; 14 h in individual workdays; 3.64 h on average in November, 4.64 h in October), and the greatest number of work days (Fig. 4) in these months (maximum up to 31 days, 18–23 on average).

High values of the total exposure to noise obtained in April are associated with intensive field activities, such as: ploughing, harrowing, sowing, disk harrowing, and

Table 1. Statistical values concerning total monthly exposure to noise in $Pa^2 \cdot h$.

Months	Mean ± SD	PU	α	k	Range	p
January	58.0 ± 58.2	16.99–88.97	1.21	0.81	0.9–197.6	0.59
February	49.5 ± 39.2	28.64–70.39	0.73	-0.17	1.6–134.3	0.94
March	60.0 ± 61.9	27.05–93.02	1.64	1.93	3.1–211.2	0.23
April	117.2 ± 87.4	70.60–163.78	1.18	0.90	23.5–319.9	0.58
May	85.1 ± 71.1	44.05–126.15	1.27	1.91	12.8–264.3	0.83
June	59.9 ± 41.2	37.09–82.69	1.60	3.60	8.7–175.1	0.58
July	45.0 ± 37.3	24.30–65.64	1.37	1.73	5.5–138.6	0.49
August	139.3 ± 94.7	83.78–184.72	1.13	0.88	33.7–366.7	0.68
September	145.4 ± 101.5	91.32–199.49	0.98	0.92	15.2–394.1	0.76
October	137.8 ± 85.2	92.40–183.25	1.86	5.32	17.4–396.5	0.53
November	116.2 ± 95.8	65.13–167.27	1.27	1.34	3.0–351.1	0.40
December	88.7 ± 111.1	29.48–147.90	2.38	6.69	2.0–441.9	0.25
For whole year	91.60 ± 37.06	68.05–115.14	0.20	-1.70	44.97–145.41	0.61

Mean – mean arithmetic value; SD – standard deviation; PU – confidence interval; α – skewness coefficient; k – kurtosis; Range – (min-max) range; p – probability normal distribution.

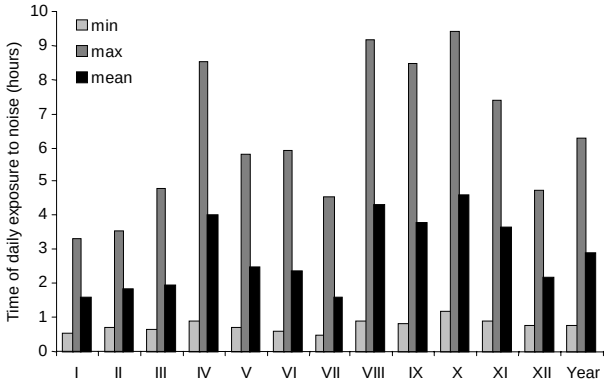

Figure 3. Time of daily exposure to noise in individual months.

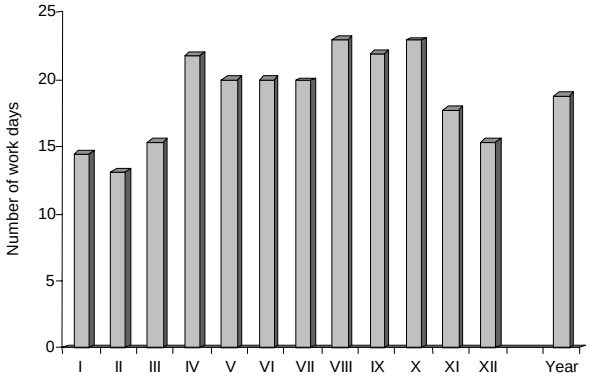

Figure 4. Mean number of workdays during a month for exposure to noise.

prolonged exposure time to this factor (maximum to 11 h; 4.03 h on average). The mean value for the total exposure for the whole year was: 91.60 ± 37.06 $Pa^2 \cdot h$, with the data distribution equivalent to normal distribution (Kołmogorow-Smirnow test; p = 0.61).

For a more objective indicator of exposure, i.e. the mean equivalent daily exposure to noise (Tab. 2) the data obtained shows that the variation in mean values is considerably smaller than in the case of the previously discussed parameter (the mean values are within the range: 2.04–6.56 $Pa^2 \cdot h$). As before, (for total exposure to noise), the greatest dispersion of data was noted in 2 months: December and March, due to the relatively high values of standard deviations and high values of skewness coefficients (α = 1.62 - 2.38) and kurtosis (k = 1.91 - 6.69). The distribution of data which best met the requirements of the normal distribution occured in the following 3 months: February (p = 0.94), May (p = 0.82), and September (p = 0.76).

The distribution of the calculated values of confidence intervals for this acoustic parameter remains similar to the total exposure (the smallest width of confidence interval being observed in the following 6 months: February, April, June, August, September and October; whereas the greatest width was noted in the remaining months).

The analysis of variance showed that the results of studies obtained for the equivalent daily exposure to noise are characterised by a relatively high variation (F test = 3.583, p = 0.0001), while Level test indicates that this variation is non-homogenous (S = 2.151, p = 0.019). Duncan test shows that significant differences concerning mean values of equivalent daily exposure occur between July, February and March, and November, April, August, October and September; and between January and June, and August, October and September.

Analysis of the data shows that the highest values of the mean equivalent daily exposure (Fig. 5) were observed in September (6.61 $Pa^2 \cdot h$), October (6.56), August (6.10), November (5.53) and April (5.58).

With relation to standard values (standard = 1.01 $Pa^2 \cdot h$ for 8 h) the registered data concerning mean equivalent daily exposure to noise exceed the allowable values by 2–

Table 2. Statistical values concerning mean equivalent daily exposure to noise in $Pa^2 \cdot h$.

Months	Mean ± SD	PU	α	k	Range	p
January	2.76 ± 2.77	1.29–4.24	1.21	0.81	0.04–9.41	0.58
February	2.48 ± 1.96	1.43–3.52	0.73	-0.18	0.08–6.72	0.94
March	2.63 ± 2.69	1.20–4.06	1.62	1.91	0.13–9.18	0.22
April	5.58 ± 4.16	3.36–7.80	1.18	0.90	1.12–15.23	0.59
May	4.26 ± 3.56	2.20–6.31	1.27	1.91	0.64–13.22	0.82
June	2.85 ± 1.96	1.77–3.94	1.60	3.61	0.41–8.34	0.58
July	2.04 ± 1.70	1.11–2.98	1.38	1.73	0.25–6.30	0.49
August	6.10 ± 4.31	3.81–8.40	1.13	0.88	1.53–16.67	0.68
September	6.61 ± 4.61	4.15–9.07	0.98	0.93	0.69–17.92	0.76
October	6.56 ± 4.06	4.40–8.72	1.87	5.33	0.83–18.88	0.51
November	5.53 ± 4.56	3.10–7.97	1.27	1.34	0.14–16.72	0.40
December	3.86 ± 4.83	1.28–6.43	2.38	6.69	0.09–19.21	0.25
For whole year	4.27 ± 1.72	3.18–5.37	0.16	-1.80	2.05–6.61	0.65

Mean – mean arithmetic value; SD – standard deviation; PU – confidence interval; α – skewness coefficient; k – kurtosis; Range – (min-max) range; p – probability normal distribution.

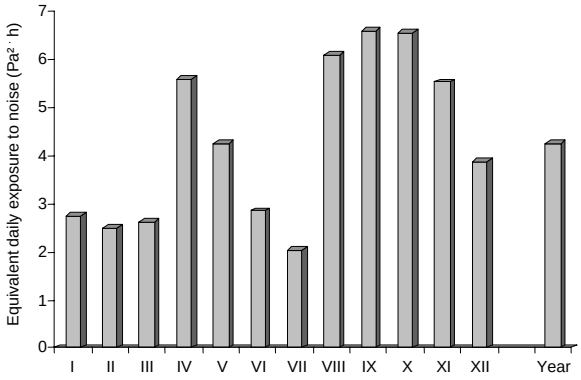

Figure 5. Mean values of equivalent daily exposure to noise (with relation to legally accepted workdays) in individual months.

6.6 times during the whole year, with the highest allowable values exceeding noted in 5 months: from August–November and in April (5.6–6.6 times).

The mean value calculated for the whole year for the mean equivalent daily exposure to noise was 4.27 $Pa^2 \cdot h$ (standard exceeded by 4.3 times). This value is equivalent to the mean level of exposure to noise referred to an 8-h workday ($L_{EX,8h}$), equal to 91.3 dB (standard: 85 dB-A).

DISCUSSION

The study of annual exposure to noise among private farmers specializing in mixed production (plant-animal) showed the great complexity and changeability of results in the time interval covering the whole year. Such a high complexity of results and wide data distribution is confirmed by high values of standard deviations obtained in individual months, wide range of the values measured (rank), wide confidence intervals, and data distribution different from normal distribution. This character of the results obtained is associated with performance of variable and complex agricultural activities in proper time intervals, with the types if agricultural tractors applied and agricultural machines matched with these tractors, excessively noisy machines used for wood logging, as well as the application of workshop machinery producing high noise levels (angular and bench grinders, drills, etc.), as well as machines for the production of fodder (grinding mills, grain crushers, and fodder mixing machines).

The degree of noise load among private farmers, on the one hand, is conditioned by the level of noise emitted by these machines, and on the other, by the duration of exposure to this factor within a proper time interval.

The study showed that for farms of mixed-production profile the mean equivalent daily exposure to noise for the whole year reached the value: 4.27 $Pa^2 \cdot h$, which is equivalent to the mean level of exposure to noise: 91.3 dB-A. This parameter obtained the highest values in the following 5 months: September, October, August, November and April (5.53-6.61 $Pa^2 \cdot h$). The occurrence of high values of equivalent daily exposure to noise in these moths was due to the performance of intensive field and transport activities (harvesting of cereals and root plants, soil cultivation and transport of the yield).

Similar results for the annual exposure to noise were obtained for farms engaged in plant production [7]. The mean value of average equivalent daily exposure to noise registered for the whole year for this type of farm reached a value equal to 4.35 $Pa^2 \cdot h$ - equivalent to the mean level of exposure to noise: 91.4 dB-A.

In the case of farms engaged mainly in animal production (dairy cattle and/or swine breeding) the noise risk was lower. The calculated mean equivalent daily exposure to noise for the whole year was: 3.61 $Pa^2 \cdot h$ - equivalent to the mean level of exposure: 90.5 dB-A [9].

There are a few reports in the literature dealing with the evaluation of annual exposure to noise among farmers. These are studies conducted by Mieńszow [2], Franzinelli [1] and Miettinen [3]. The results obtained by Franzinelli and Miettinen are the closest to the data obtained in the presented study.

CONCLUSIONS

1. The studies of annual exposure to noise conducted among private farmers specializing in mixed production (plant-animal) showed a relatively high load for the organ of hearing caused by this factor (mean level of exposure to noise for the whole year = 91.3 dB-A), considerably exceeding allowable values.
2. An especially high noise risk was noted in April, August, September, October and November (6 times exceeding allowable values for exposure to noise - $E_{A,8h}$).
3. The results of this study are close to the data obtained by other authors, and confirm that the degree of noise risk among private farmers depends on the type of agricultural production and type of machines used.
4. The results of studies obtained to-date clearly show that decisively the greatest noise load is observed on farms engaged in plant production (level of exposure to noise: 91.4 dB-A) and mixed production (91.3 dB-A), whereas on farms carrying out animal production this load is lower (90.5 dB-A); however, it also exceeds the standard.
5. The results of the presented study are of great value from the cognitive and practical aspects and may be used by the Sanitary Inspectorate, Labour Inspectorate, as well as the Agricultural Social Insurance Fund (KRUS) and the Regional Centres of Occupational Medicine (WOMPs) in order to assess noise risk among private farmers engaged in an individual agricultural production profile, and for technical, organizational and medical prophylaxis.

REFERENCES

1. Franzinelli A, Maiorano M, De Capua B, Masini M, Vieri M, Cipolla G: Annual dose of noise absorbed by machine drivers in wine and cereal growing. *G Ital Med Lav* 1988, **10**, 131-134.

2. Mieńszow AA, Sota WN: Dose evaluation of noise load among agricultural machines operators. *Gig Truda i Prof Zabol* 1984, **10**, 36-38 (in Russian).

3. Miettinen U, Rytkonen E, Husman K: *Exposure of farmers to noise. Tyoterveyslaitos.* Laajaniityntie 1. 01620 Vantaa, Finland 1982. 31p.

4. Polish Standard PN-N-01307: *Noise. Allowable values of sound level at workplaces and general requirements concerning measurements*. Polish Standardisation Committee. Ed. Standardisation. ALFA-WERO. Warsaw 1994 (in Polish).

5. Solecki L, Zagórski J, Horoch A, Wasilkowski J, Krawczyk M, Skrzek W, Bychawska M: *Recognition of exposure to noise and occupational hearing loss among private farmers on selected family farms*. [Report from Project No. 2.17/96]. Institute of Agricultural Medicine, Lublin 1998 (in Polish).

6. Solecki L: Preliminary analysis of annual exposure to noise among private farmers. *Zastosowania Ergonomii* 1999, **(34/35), 2/3**, 89-97 (in Polish).

7. Solecki L: Evaluation of annual exposure to noise among private farmers on selected plant production family farms. *Med Pr* 2004, **55**, 175-182 (in Polish).

8. Solecki L, Lewkowicz R, Wasilkowski J, Bychawska M: *Determination and evaluation of annual exposure to noise among private farmers on selected family farms of various production profiles*. [Report from Project No. 2.17/02] (2002-2004). Institute of Agricultural Medicine, Lublin 2004 (in Polish).

9. Solecki L: Evaluation of annual exposure to noise among private farmers on selected family farms of animal production profile. *Ann Agric Environ Med* 2005, **12**, 67-73.

10. *Statistical data analysis: SPSS/PC + 4.0 Base manual for the IMB-PC/XT/AT and PS/2, SPSS INC. 444N*. Michigan Avenue, Chicago, Illinois 60611, 1988.