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SUSTAINABLE DEVELOPMENT OF TECHNOLOGY OF CATTLE BREEDING SYSTEMS

Summary

Properly designed housing buildings, with regard of reduction of negative influence on environment are necessary to ensure a sustainable development in agriculture. The aim of this paper was to show the results of environmental conditions research inside 3 cowsheds for high milk yield dairy cattle in different housing systems. Temperature and relative humidity of air and accompanying them concentrations of harmful gases of ammonia and carbon dioxide were researched.
***Key words**: sustainable development, cattle breeding systems, harmful gases, environment protection, animal welfare, energy balance*

ZRÓWNOWAŻONY ROZWÓJ TECHNOLOGII CHOWU BYDŁA

Streszczenie

Prawidłowo zaprojektowane budynki inwentarskie, przy uwzględnieniu ograniczenia negatywnego oddziaływania na środowisko naturalne są niezbędne dla zapewnienia zrównoważonego rozwoju w rolnictwie. Celem pracy było przedstawienie wyników badań warunków środowiskowych wewnątrz 3 obór dla wysokowydajnych krów mlecznych w różnych systemach utrzymania. Zbadano w szczególności temperaturę i wilgotność względną powietrza oraz towarzyszące im stężenia szkodliwych gazów amoniaku i dwutlenku węgla.
***Słowa kluczowe**: zrównoważony rozwój, systemy utrzymania zwierząt, szkodliwe gazy, ochrona środowiska, dobrostan zwierząt, bilans energetyczny*

1. Introduction

Rational development of technology in agriculture connected with animal production is very close to some very important parameters as: genetic progress, EU requirements for well being of animals living in restricted area, existing limitations of environment protection and general expectations for the quality of a final product. It is proved that exhausted air from cattle barns contains quite harmful components as: ammonia, methane, hydrogen sulfide, nitrous oxide, germs and dust [1, 5].

The goal of research was evaluation of influence of different factors on sustainable development of agriculture technology on the example of cattle breeding systems and odor management in different aspects of technology development. Besides that influence of manure management on environment protection in a country area was pointed out.

2. Material and methods

The scope of research were analysis of three cattle barns of different breeding technology located on family farms with high – V level of mechanization. All barns had loose housing systems but different organization of manure removal. So one of barn had litter in a cattle boxes, another one had no litter but rubber mats and the last one had deep litter pens [3, 4].

The analysis concerning environment protection, were based on the following restrictions:

- carbon dioxide $CO_2 \leq gr\ CO_2$ (3000 ppm);
- ammonia $NH_3 \leq gr\ NH_3$ (20 ppm);
- hydrogen sulphide $H_2S \leq gr\ H_2S$ (0,5 ppm) [6].

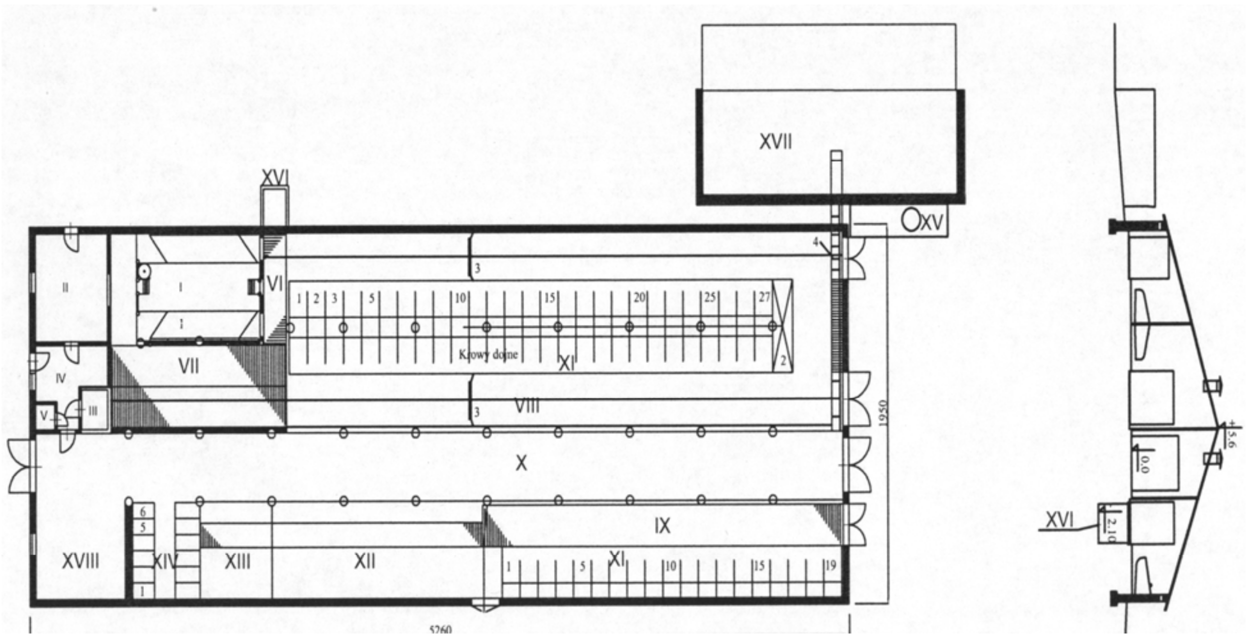
Also some tests concerning relationship of existing environment parameters and harmful gases concentration inside the barn according to EU regulations were provided.

All mentioned barns are presented below in a scheme way on three separate figures (fig. 1-3).

3. Results

Principal objective of this study was to determine the influence of environment condition on animal welfare.
Intensive breeding of animals, as a response to increasing meat and milk consumption at present, effects that agriculture is one of the most nuisance sector to the environment. It is connected with the necessity of providing larger and larger agricultural areas for cropping animal feeds, and with production of very large amounts of slurry, creating strong environmental load.

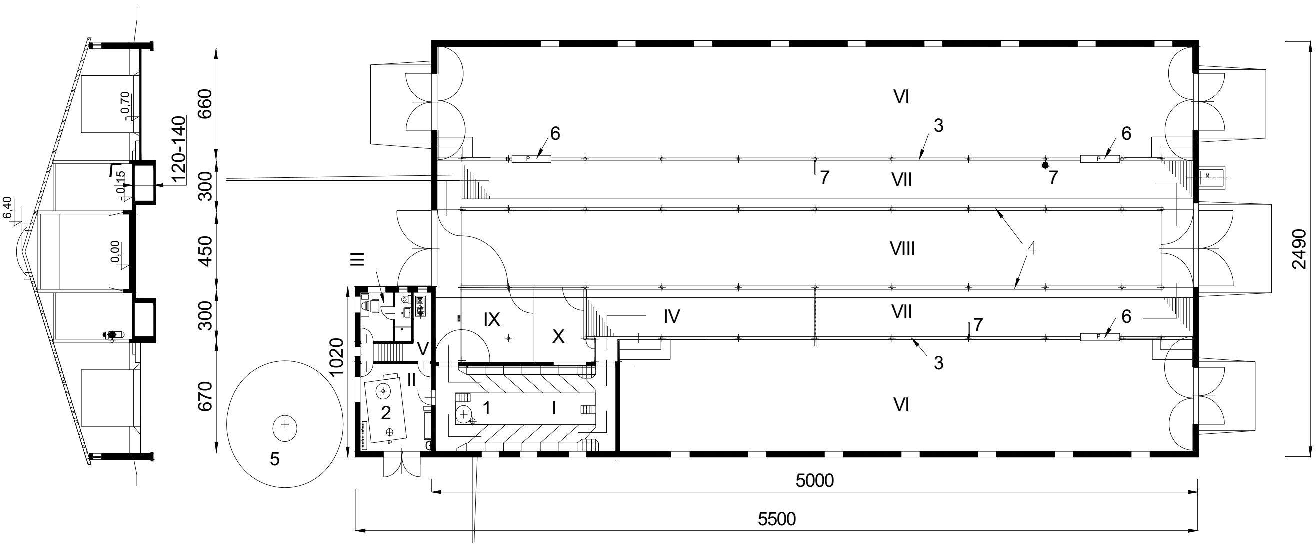
In all presented cattle barns relative humidity of air exceeded the optimum. Average relative air humidity inside of tested the cattle barns, ranged from 60.1 to 77.12%, whereas the particular readings oscillated within 26.4–99.9%.



Source: Own study, źródło: opracowanie własne

Fig. 1. Scheme of loose housing barn with litter in boxes: I – milking parlour – „herring bone” 2x5, II – milking room, III – power supply, IV – sanitary room, V – social room, VI – waiting room before milking, VII – waiting room after milking, VIII – feeding area for milking cows, IX – feeding area for dry cows, X – feeding corridor, XI – boxes for cows, XVI – liquid manure tank, XVII – solid manure plate, 2 – double feeding station, 3, 4 – manure scraper

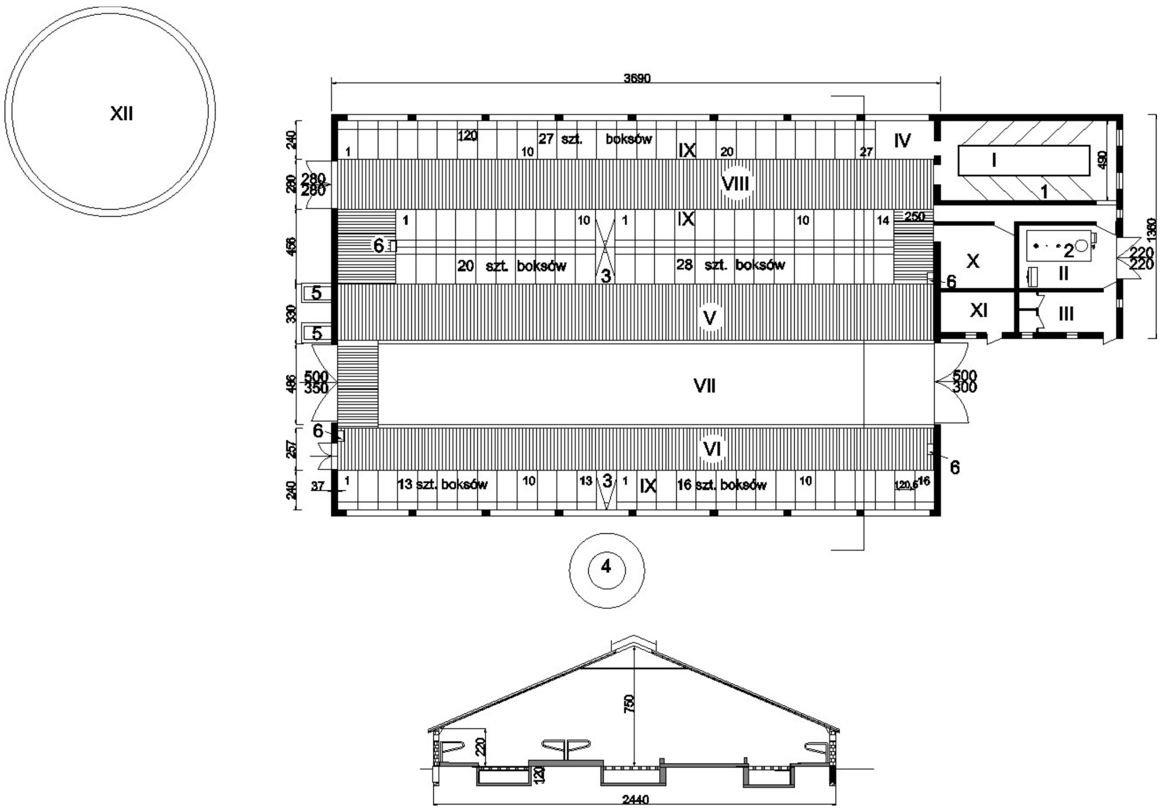
Rys. 1. Schemat obory wolnostanowiskowej boksowej z płytką ściółką: I – dojarnia „rybia ość „2x5”, II – pomieszczenie na mleko, III – maszynownia, IV – pomieszczenie sanitarne, V – pomieszczenie socjalne, VI – poczekalnia przedudojowa, VII – poczekalnia poudojowa, VIII – obszar paszowy dla krów dojnych, IX – obszar paszowy dla krów zasuszonych, X – korytarz paszowy, XI – boksy dla krów, XVI – zbiornik gnojowicy, XVII – płyta obornikowa, 2 – stacja paszowa dwustanowiskowa, 3, 4 – zgarniak obornika



Source: Own study, źródło: opracowanie własne

Fig. 2. Scheme of loose housing barn with deep litter: I – milking parlour, II – milk storage room, III – office, IV – waiting room, V – engine room, VI – pens with deep litter for cows, VII – feeding area on the slotted floor, VIII – feeding corridor, IX – delivery room, X – calf shed, 1 – herringbone milking parlour 2x6, 2 – milk cooling tank, 3 – wall, 4 – feeding barrier, 5 – silo for concentrate feeds, 6 – drinking bowl, 7 – scratcher

Rys. 2. Schemat obory wolnostanowiskowej z legowiskiem na głębokiej ściółce: I – dojarnia, II – pomieszczenie na mleko, III – biuro, IV – poczekalnia, V – maszynownia, VI – kojce z głęboką ściółką dla krów, VII – obszar paszowy na podłodze szczelinowej, VII – korytarz paszowy, IX – porodówka, X – cielętnik, 1 – dojarnia rybia ość 2x6, 2 – schładzarka, 3 – przegroda rozdzielająca, 4 – przegroda paszowa, silos na pasze treściwe, 6 – poidło, 7 – czochradło

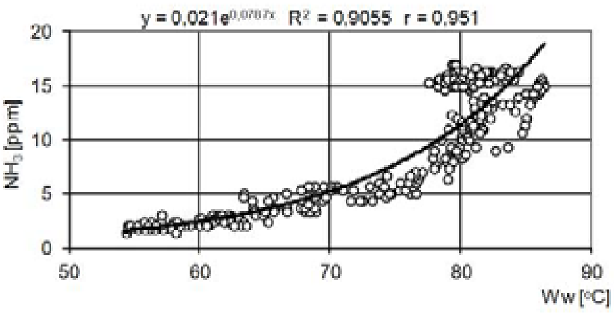


Source: Own study, źródło: opracowanie własne

Fig. 3. Scheme of loose housing barn with slotted floor and no litter in a boxes: I – milking parlour „herring bone" 2x5, II – milking room , III – social room, VII– feeding corridor, V, VI, VIII – slotted floor , IX – boxes for milking cows, 3 – feeding station

Rys. 3. Schemat obory wolnostanowiskowej bezściółkowej boksowej z podłogą szczelinową: I – dojarnia „rybia ość" 2x5, II – pomieszczenie na mleko, III – pomieszczenie socjalne, VII – korytarz paszowy, V, VI, VIII – podłoga szczelinowa, IX – boksy dla krów mlecznych, 3 – stacja paszowa

Relationship between NH_3 concentration and relative humidity of air inside the cattle barn with rubber mats presented in figure 4.

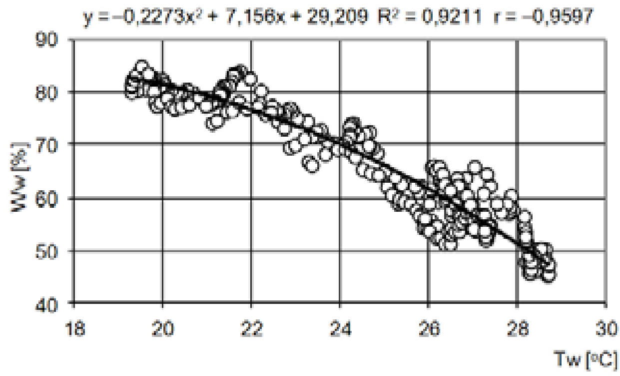


Source: Own study, źródło: opracowanie własne

Fig. 4. Relationship between NH_3 concentration and relative humidity of air inside the cattle barn (boxes with litter). Number of freedom degrees n–1 = 288; confidence level P = 0.01

Rys. 4. Zależność między stężeniem NH_3 i wilgotnością względną w oborze dla krów (boksy ze ściółką). Liczba stopni swobody n-1 = 288, poziom ufności P = 0.01

Relationship between air temperature and relative humidity inside the cattle barn with litter presented in figure 5.



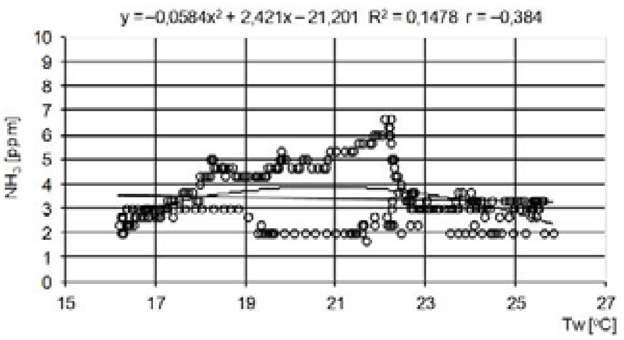
Source: Own study, źródło: opracowanie własne

Fig. 5. Relationship between air temperature and relative humidity inside the cattle barn (boxes with litter). Number of freedom *degrees n–1 = 288; confidence level P = 0.01*

Rys. 5. Zależność między temperaturą i wilgotnością względną w oborze (boksy ze ściółką). Liczba stopni swobody n–1 = 288, poziom ufności P = 0.01

Average concentration of carbon dioxide in all the cattle barns did not exceed 1000 p.p.m., what is recognized as the comfortable conditions. Particular CO_2 concentrations, varying from 280 to 2900 p.p.m., were comprised within standard accepted limits. Average ammonia concentration in tested objects was situated in the range from 3.39 to 8.72 p.p.m., what does not exceed allowable limits.

Relationship between NH_3 concentration and air temperature inside the cattle barn with deep litter presented in figure 6.

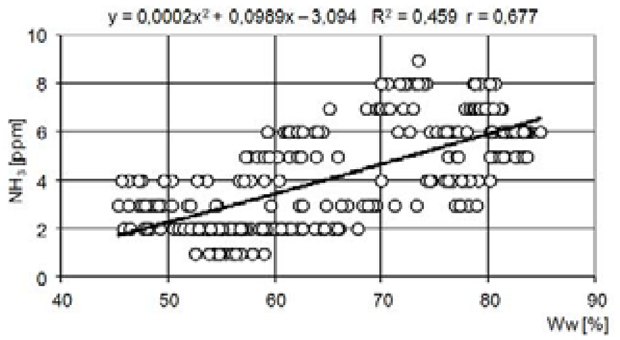


Source: Own study, źródło: opracowanie własne

Fig. 6. Relationship between NH_3 concentration and temperature inside the cattle barn (deep litter). Number of freedom degrees n–1 = 288; confidence level P = 0.01

Rys. 6. Zależność między stężeniem NH_3 i temperaturą w oborze (głęboka ściółka). Liczba stopni swobody n – 1 = 288, poziom ufności P = 0.01

Relationship between NH_3 concentration and relative humidity inside the cattle barn with litterless boxes presented in figure 7.



Source: Own study, źródło: opracowanie własne

Fig. 7. NH_3 concentration depending on relative humidity of air inside the cattle barn (litterless boxes). Number of freedom degrees n–1 = 288; confidence level P = 0.01

Rys. 7. Stężenie NH_3 w zależności od wilgotności powietrza wewnątrz obory dla krów (boksy bezściókowe). Liczba stopni swobody n–1 = 288; poziom ufności P = 0.01

Nitrogen in the manure, exactly as the ammonium, is a source of pollution of all environment's elements [2].

Manure utilization in the way of generation and usage of agricultural origin energy, give some chances to diversify and increase the agricultural incomes and rural energetic security, as well as to improve the environment protection in the country side.

According to the Ministry of Agriculture, at considering the possibilities of using biomass of agricultural origin for energy purposes, long-term prospects and tasks for the agriculture should be taken into account. It has been assumed that until the year 2050 food production on the world scale can be doubled.

Above mentioned aim requires not only increasing the unitary production, but also supporting the accessible potential of agricultural production at proper culture, until it will be intended in total to food production. It is promoted by actual assignment of production surpluses for energy purposes, until the moment, when advanced technology will enable to use the other renewable energy carriers.

In many cases, a farmer can and should not only supply the raw material, but also produce the electric and thermal energy, or be a supplier of biogas purified to the quality of natural gas, to the gas distribution network.

4. Discussion and conclusions

Average ammonia concentration in tested objects was situated in the range from 3.39 to 8.72 p.p.m., what does not exceed allowable limits.

Also particular CO_2 concentrations, varying from 280 to 2900 p.p.m., were comprised within standard accepted limits.

Loose housing system with slotted floor and no litter in boxes, had promising results and obtained the following parameters:

- CO_2 concentration in the range from 920 ppm to 1850 ppm and average value of 1456 ppm,
- NH_3 concentration in a range of 0,5-16,0 ppm and average of 10,5 ppm.

Generation and usage of agricultural origin energy, give some chances to diversify and increase the agricultural incomes and rural energetic security, as well as to improving the environment protection of agriculture land.

Table 1. Measurements of environment parameters during research observations

Tab. 1. Parametry mikroklimatu uzyskane podczas prowadzonych badań

Cow barn	Temperature [°C]		Relative humidity [%]		Gas concentration		Katathermometric cooling [W·dm^{-2}]	Air movement velocity [m·s^{-1}]		Lighting [lx]
					CO_2 [ppm]	NH_3 [ppm]				
	average outside	average inside	average outside	average inside	average	average		Katathermometer	Thermo-anemometer	
	Range	Range	Range	Range	Range	Range		average	average	
1	5,10 1,7–10,8	11,50 7,6–15,8	72,00 41,0–90,3	60,30 36,0–73,5	932,60 500–1900	4,50 1–9	1,53	0,17	0,7242	140,00
2	18,26 11,4–25,2	21,02 15,7–29,6	-	64,08 39,5–80,5	718,04 300–1600	3,41 1–8	2,39	0,16	0,6416	212,20
3	22,87 16,7–31,6	17,72 11,9–21,8	79,92 40,8–94,6	68,8 46,0–93,0	665,50 300–1500	6,10 1–19	2,70	0,20	0,6832	124,25

Source: Own study, źródło: opracowanie własne

That is a chance to improve an environment in the country side by development of new energy sources and biogas production could be one of them [2].

The carried out experiments has proved that it is possible to obtain the following results:

- Reduction of greenhouse gases by about 20 percent.
- Improvement of effectiveness of energy utilization by about 20 percent (lower usage of original energy).
- Increase of usage renewable energy sources in a total energetic energy balance on a country scale by about 20 percent.

5. References

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