FORMALIZATION OF CRITERIA FOR DETERMINING BEST AVAILABLE TECHNOLOGIES: THE CASE OF RUSSIA

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Abstract. In Russia there are introduced the principles of best available technology (BAT), created for economically viable and environmentally sound business activities that have been effective as a result of the use in the EU. However, so far, provisions and recommendations of this approach are not specific and can be used by only highly qualified experts. The authors see the solution of this problem by a more rigorous formalizing system of criteria and algorithm for technology selection. This article presents an example justification of the criteria and their application when deciding on the choice of BAT in intensive livestock farming in Russia. In particular, we consider the development of a BAT structure in accordance with processes at livestock farms. Also, the article considers the economic calculation of damages from different types of agricultural pollution. The authors suggest a method to determine environmental effectiveness of technology based on nitrogen use efficiency. In preparing the article we used the results of the Russian-German project "Project 43086. Best available techniques (BAT) for intensive rearing of pig, poultry and cattle in EECCA countries – support of implementation of Gothenburg Protocol of the UNECE-CLRTAP and environmentally sound techniques according to the EU Industrial Emission Directive (IED)".

Keywords: best available technology, manure processing, nutrients, nitrogen, phosphorous, nutrient losses.

Introduction

Modern agriculture has a significant negative impact on the environment. And the biggest negative impact comes from agricultural enterprises with livestock and poultry manure being the main source of pollution. Leningrad region is an example of a territory with serious difficulties as far as the situation with manure is concerned. According to official data only 35 % of all generated manure is used to produce fertilizers. And the reason for that is the prevalence of the livestock sector over the crop sector, very high share of inexpensive forage crops, unhelpful location of farms (requiring to transport fertilizers over long distances), and low nutrient value of fertilizers (high water content).

Currently the legal framework for environment protection is being reformed in order to improve the situation with negative impact on the environment. On 1 January, 2015, the Federal Law of the Russian Federation No. 219-FZ "Concerning the Introduction of Amendments to the Federal Law "On Environmental Protection" and Certain Legislative Acts of the Russian Federation" came into force (previously adopted on 21 July, 2014). This Law should serve as a basis for the introduction of the Best Available Techniques – BATs.

The Law defines a Best Available Technique as a complex of production processes, equipment, engineering methods, techniques, procedures and tools, which are based on the latest achievements of science and technology, have the best combination of indicators describing the achievement of environment protection and economic efficiency goals, and feature technical applicability in production on the facilities that have an adverse impact on the environment.

The Best Available Technique is identified by the following criteria:

- The lowest level of negative environmental impact per unit of time or volume of production;
- Cost-effective introduction and operation;
- Application of resources and energy saving methods;
- Time span for its introduction;
- Commercial application of this technique on two or more facilities, which have a negative impact on the environment.

Environmental regulation based on BAT principles implies that there should also be methods of economic influence on enterprises, which, in turn, raises questions regarding transparency of the BAT identification procedure. Analysis of European BREF document showed that experts have great leeway in organizing these procedures. However, it increases the risk of a wrong decision being made, so it is preferable to have a more strict formalization and scientific rationale of these procedures. Materials presented in this paper are the result of the Russian-German EECABAT project the goal of

which is to develop recommendations on implementation of the BAT system in Russia on the base of European experiences.

Materials and methods

This research required analyzing regulatory documents on BAT for the EU [1; 2], current official Russian documents [3] and literature with data on negative impact of livestock farming on the environment [4-7].

In order to perform BAT identification we examined the procedure presented in the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs (2003) [1].

According to this procedure, all technologies are examined separately by assessing them according to the BAT criteria and comparing them to base (traditional) technologies.

Assessment of technologies is being made with the expert survey method.

The main steps in BAT identification are as follows.

1. To create an assessment matrix of all the relevant factors for each group of techniques (machinery, technologies, processes);
2. To identify the reference technique (to be compared with) for each group of techniques. The reference (basic) techniques is the most common one.
3. To identify the key environmental issues for each group of techniques;
4. To give a qualitative rating (-; 0; +) for each technique, where quantitative data are not available. Rating score '0' corresponds to the reference techniques rating. Technique with stronger negative environmental impact than the reference technique gets a rating score '-'. Technique with smaller environmental negative impact than the reference technique gets a rating score '+'.
5. To rank the techniques by their environmental performance in terms of, for example, reduction of ammonia emissions;
6. To assess the technical applicability, the operability and the animal welfare aspects of each technique;
7. To assess the environmental cross-media effects caused by each technique;
8. To estimate the costs (CAPEX and OPEX) of applying each technique in new and in retrofit situations;
9. To identify BAT and to decide if this BAT will be used for a new construction or will be retrofitted for an old construction. As a result of BAT identification of the techniques is determined BAT categories of this techniques: category "0" – is not BAT, category "I" – BAT, category "II" – is conditional BAT.

Development of the BAT structure is factored in the approach used in the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs [1; 2].

Every process should be assessed according to relevant criteria, and then on the basis of these assessments enterprises are deemed as either utilizing or not utilizing BAT technologies. If at least one process uses techniques or methods that do not comply with BAT technologies then the entire enterprise is considered not utilizing BAT technologies.

Results and discussion

In order to assess enterprises we developed a BAT structure in accordance with processes at livestock farms.

- Inside livestock buildings:
  - feeding system;
  - livestock housing system;
  - layout design of the buildings;
  - drinking system;
  - indoor climate (ventilation, heating, lighting) ;
  - manure removal.
- Outside livestock buildings:
  - collection and storage of manure;

- processing of manure;
- soil application of manure.

We took each technology and analyzed how the values of its elements affect the negative impact on the environment. Table 1 shows the results of importance of assessment of BAT values for technological elements. This table was compiled according to the results of expert surveys.

Table 1

Assessment of technological elements in terms of BAT criteria

Key assessment indicators		Livestock facility						Animal/ Poultry manure storage	Animal/ Poultry manure processing	Field application of processed animal/ Poultry manure
		Housing system	Ventilation system	Feeding system	Drinking system	Manure removal system	Medication lighting, etc.			
Emissions to atmosphere	Ammonia / odour	X	X	X	-	X	X	-	X	X
	PM (PM10)	X	X	-	-	X	(X)	X	-	(X)
	Methane	X	-	X	-	X	-	X	X	X
	Nitrogen oxide	X	-	X	-	X	-	X	X	X
	Other (noise, CO2, NOx, SO2)	X	X	X	-	X	X	X	X	X
	Dust	X	X	-	-	X	-	-	X	X
Risk of N and P access to soil		-	-	-	-	-	-	(X)	X	X
Resources	Power inputs	X	X	X	X	X	X	X	X	X
	Water consumption	-	-	X	X	X	X	-	X	X
Animal health		X	X	X	X	X	X	-	-	-
Animal comfort		X	X	X	X	X	X	-	-	-
Economic indicators		X	X	X	X	X	X	X	X	X
Operating experience		X	X	X	X	X	X	X	X	X

("X" is relevant for the criterion, "–" is not relevant for the criterion, (X) – possibly relevant)

Economic calculation of damages from different types of agricultural pollution showed that manure is the most significant source of negative impact on the environment (Fig. 1). Nitrogen and phosphorus losses lead to acidification and eutrophication of surface waters, pollution of ground waters and deterioration of human health.

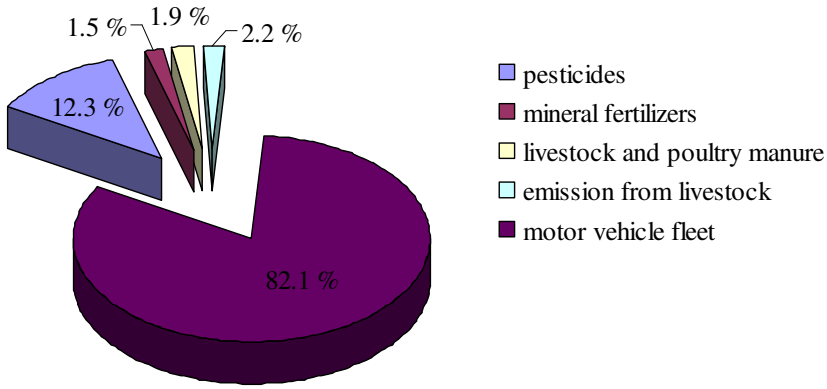

Fig. 1. **Distribution of damage to the environment from different sources within livestock farms**

Analysis of possible nitrogen losses performed on experimental and documented data showed that most losses occur outside the places where livestock is kept – during manure processing and its application to the fields in the form of fertilizer (Fig. 2).

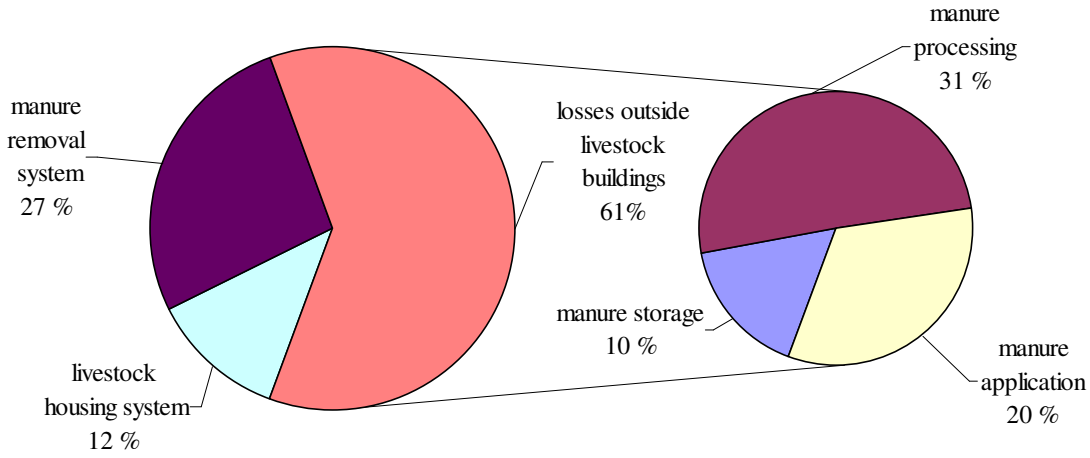

Fig. 2. **Distribution of nitrogen losses from livestock farms**

This is why technologies for manure processing were examined in more detail.

Examples of expert assessments for technologies in the context of Northwestern Federal District are presented in Table 2.

This assessment matrix shows the values of the key indicators of BAT criteria for the reference technology and five BAT candidates. Depending upon the technologies, some key indicators may be added or changed. The first group of indicators (items 1-6) are related to air emissions; the second group (item 7) – emission to soil/water; the third group (item 8) – to resources; the fourth group (items 9-10) – are economic indicators; the fifth group (item 11) is operating experience; item 12 is decision making on rating as BAT with a certain category.

When considering the first group of indicators the experts noted the advantages of the candidates No. 2, 4 and 5 by the ammonia, methane and nitrogen oxide emissions level [8] owing to the cover on manure storages, which prevents atmospheric emissions.

All the technologies under consideration prevent the risk of nitrogen and phosphorus access to water and soil as they all incorporate waterproofing techniques.

All the BAT candidates help reduce the power supply level compared to the reference technology owing to the lower power consumption for manure unloading from the storage and loading it to the vehicle.

When estimating the operating experience, the risk of plastic film damage was noted; the candidates No. 1 and 4 may feature the access of precipitation to manure. For the conditions of the North-West Federal District of Russia all the technologies under consideration may be identified

(rated) as BAT despite the substantial capital costs; the reference technology cannot be BAT as it is not environmentally sound.

Table 2

Expert assessment of technologies for application of liquid organic fertilizers

Key assessment indicators		Reference (base) technology*	BAT candidate 1*	BAT candidate 2*	BAT candidate 3*	BAT candidate 4*	BAT candidate 5*
Air emissions	Ammonia	**0**	**+**	**+**	**+**	**+**	**+**
	Odour	**0**	**0**	**0**	**0**	**0**	**0**
	CH_4	**0**	**0**	**0**	**0**	**0**	**0**
	N_2O	**0**	**0**	**0**	**0**	**0**	**0**
	PM	**0**	**0**	**0**	**0**	**0**	**0**
	Dust	**0**	**0**	**0**	**0**	**0**	**0**
	Puddling	**0**	**0**	**0**	**+**	**+**	**+**
Water/soil emissions		**0**	**0**	**+**	**+**	**+**	**+**
Power input		**0**	**0**	**-**	**-**	**-**	**-**
Economical indicators	Capital costs	**0**	**-**	**-**	**-**	**-**	**-**
	Operating costs	**0**	**-**	**-**	**-**	**-**	**-**
	Labour	**0**	**0**	**0**	**0**	**0**	**0**
Practical experience		0	+	-	-	-	-
BAT		**0**	**I**	**I**	**I**	**I**	**I**

* **Reference (base) technology -** Surface spray application of liquid organic fertilisers on perrenial grass;
BAT candidate 1 – Surface application with boom system with mounted flexible hoses;
BAT candidate 2 – Surface application with boom system with mounted flexible hoses with nozzles;
BAT candidate 3 – Subsurface application to the depth from10 to 25 cm with the working tool as a cultivator tine;
BAT candidate 4 – Subsurface application to the depth from 5 to 10 cm with disk working tools;
BAT candidate 5 – Subsurface application to the depth from10 to 25 cm with disk working tools with the subsequent covering of furrows.

As the rational way to determine the technology effectiveness the authors of this paper propose to assess the costs of nitrogen saving that will depend on nitrogen use efficiency (NUE).

$$NUE = \frac{N_{outputs}}{N_{inputs}}, \quad (1)$$

where $N_{outputs}$ and N_{inputs} – annual volumes of coming and outgoing nitrogen, kg per year.

In this case calculation can be done according to the following formula:

$$C_{NS} = \frac{C_{pr}}{NUE \times N_{inputs}}, \quad (2)$$

where C_{NS} – costs of saving of total nitrogen, roubles per kg;
C_{pr} – annual costs connected to this process, roubles per year.

Conclusions

1. Economic assessment of damages from different factors showed that the biggest damage is linked to manure processing technologies.
2. Analysis of the BAT identification criteria showed that the economic and ecological (complex negative impact on the environment) criteria have the most significance, and they should be accounted for in complex.
3. The authors of this paper propose a method to assess technologies according to complex criteria that includes both ecological and economical aspects.

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