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POSSIBILITIES OF ANIMAL WASTE INCINERATION IN BOSNIA AND HERZEGOVINA

Abstract: *The subject of this paper is environmental issue of waste that originates on farms and slaughterhouses. The problem of farms and slaugterhouse waste is obviously great, and it is evident that the B&H does not pay much attention to it. It was proved that the incineration is one of the most efficient ways to eliminate dead animal and other solid waste in modern poultry production. Gaseous or liquid fuel is used in the process of incineration as an energy generating product. The main advantage of the suggested concept is the proposal to use waste as a primary energy source for incineration.*

Key words: animal waste, incineration.

INTRODUCTION

The need for a controlled solution to the issue of solid waste from poultry farms and slaughterhouses has been growing. Solid waste appears on poultry farms and in slaughterhouses in the following forms [1]:

- Dead poultry during the production process,
- Cover on the floor of the farm that consists of sawdust of wood and animal excrement,
- Slaughterhouse waste.

Basic problems of incineration, as a procedure of waste elimination, are relatively high costs as well as investments and exploitation. The expense of burning is most often expressed through the price of burning 1 kg of waste material. The devices available on the market nowadays have relatively high price, while there are other expenses related to the equipment maintenance.

In Bosnia and Hercegovina, there are both small farms (5-6 thousand chickens per one turnus) and larger farms (10-12 thousand chickens per one turnus). Considering the prices of the burners, the purchase of burner is a great financial burden for farmers.

The concept of mutual burners in the case of poultry farms in this region is not applicable since there are other problems such as waste disposal in freezers and the use of special transporting vehicles to avoid potential infection. The suggestion is a concept of small incinerations for the solution of waste issues in individual poultry farms and slaughterhouses [2]. The main advantage of the suggested concept is the proposal to use the waste generated at the farm as a prime source of energy.

ANIMAL BEDDING AS FUEL

Poultry farms generate great quantity of waste in a mixture of sawdust and bird excrement generated in the process of chicken raising. The content of moisture in this fuel is extremely high and comes to even 70%, depending on the treatment which requires its drying to be efficiently usable. Heating power of the dried fuel (moisture percentage 20%) is approximately equal to heating power of the wood with the same percentage of moisture. Proximate analysis of fuel characteristics indicates the following composition percentages based on weight:

- volatiles 61,4%
- fixed carbon 13,3%
- ash 9,0%

The ash content is characterized by: Ca (15,45%), P (9,40%), Mg (2,95%), Na (2,51%), K (7,12%). pH value of this material is 12,7 which points to high level base. Due to the high pH value of this material, it is possible to use it for fertilization only after it is left in the open for a long time. Anaerobic digestion is one of the ways to use this kind of waste.

THE CONCEPT OF FARM INCINERATORS

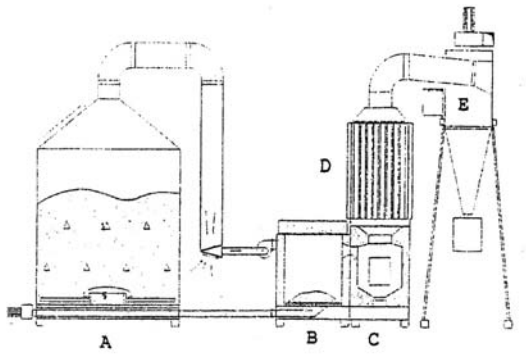
The essence of the proposed concept of farm incinerators is in gasification, the process of thermo degradation of materials with small amounts of air, where solid fuel is transformed into gaseous products that later burn out in the firebox. The temperature during this process goes up to 1200^{o}C.

The proposed solution of incinerators is given in the Figure 1. It predicts the use of additional chamber for waste incineration, the system for burning out gases, and because of the sulphur oxides that originate during the waste burning process there is a small system for desulfurization. On the other hand, if there is no need for waste burning, it enables the system to function as a heat boiler that provides the necessary heating energy for the farm. In this way the problem of cover (bedding) is solved- it serves as fuel for the purpose of heating the farm and for the periodical burning of dead poultry.

It was predicted for the system for fuel dosage (bedding) to work in an automatic manner, led by thermostatic regulation of given water temperature in

an exchanger and by thermostat of air temperature in the farm.

Therefore, the concept predicts a combination of incinerator with the boiler, since was proved to be the only economically acceptable alternative for Bosnia and Herzegovina.



A - a chamber for bedding

B - a gas chamber

C - a combustion chamber

D - heat exchanger

E - cyclone

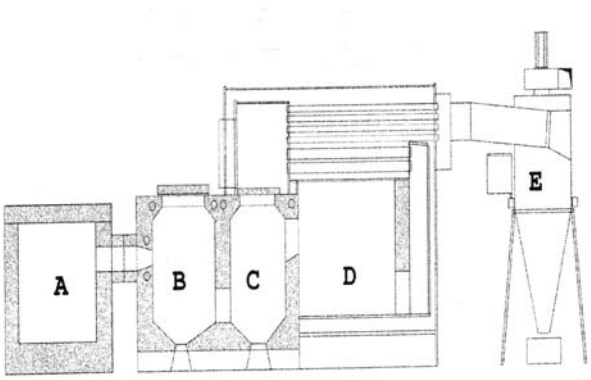
Figure 1. *Bedding burner and incinerator used in farms*

THE CONCEPT OF INCINERATOR FOR POULTRY SLAUGHTERHOUSES

We predicted somewhat different system for the slaughterhouse granted they are not integrated in the farms and not having the bedding as the potential fuel. The proposed solution is based on the use of dolts of wood as primary energy sources, as is the common practice in the region.

Similar to the previous case, the system is devised to work as an incinerator when needed, but the main aim is to produce heating energy (see Figure 2). When it comes to slaughterhouses, the system is predicted to work on a principle of manual heating of wood in dolts that would, by gasification, come to a needed temperature for burning poultry waste (app. 1200^{o}C), and the energy of burning out would be used through the heat line exchanger for heating the room and sanitary water.

Where there is no cover (bedding) as by-product in slaughterhouses, dolts of wood could be used for waste burning as much cheaper energy generating product than the liquid or gaseous fuel.



A - a gas chamber of wood piece

B - a chamber of slaughterhouse

C - the second phase of combustion

D-the third phase of combustion and heat exchanger

E - a cyclone with fan flue gases

Figure 2. *Slaughterhouse waste incinerator*

ENERGY USED IN POULTRY FARMS IN B&H

Current practice

According to the data gathered from farmers that own classic solid fuel heating boilers, their expenditure of wood goes from 70-90 m^3 in heating season (for farms of 5-6 thousand chickens) to 150-200 m^3 (for farms of 10-12 thousand chickens) which represent considerable financial burden, large space for storing and continuous presence of janitor during the heating season. The reason for this high expenditure is extremely inconvenient conditions for boilers that effect low grade of use (50-60%).

The inconvenient conditions are as follow:

- exploitation of a boiler in conditions of outside temperature above 10^{o}C, when due to low temperature there is low speed of smoke gases which cause intensive sediments of soot on inner walls of exchanger, influence heat exchange, lower temperature regime, and induce large quantity of easy evaporable flammable matters on the exit of a chimney,
- low chimneys due to low heights of the entire building which is not enough for natural pull of smoke gases and causes consequences as in the previous point,
- very inert regulation of a key for air through the regulator of draft on the principle of expansion of gas capsule,
- high percentage of moisture in wood due to inadequate storing.

Systems with gasification

A system with gasification of bedding or wood, with their own concept, solves a lot of problems above mentioned:

- high temperature regime that effects stable process of burning, low quantity of unburnt products, low stain of heating surfaces, protection of low temperature corrosion and high usefulness grade of installation,
- termostatic regulation in narrow temperature field that can be changed by program,
- artificial draft for the process not to depend on external weather conditions,
- eliminate unnecessary constant presence of janitor on installations (periodical supervision or sound alarm in the case of device interruption),
- it is possible to continue the process in a regular manual manner in a case of accidental interruptions in an automatic dosage of fuel till the repair.

Regarding the analyzed data and finished estimate concerning the bedding quantity, we conclude that 70-80% of heating energy required for farm heating can be provided from five turnuses in a year, which is significant economic and ecological effect.

ECONOMIC ANALYSIS

The economic analysis of the way solid and liquid animal excrements and dead animals on farms and slaughterhouses are taken care of show that the costs are directly proportional to the measures taken with the aim to prevent negative consequences of waste, taking into account the environmental and health influences. Low costs of waste treatment are highly risky whereas using safe methods increases the costs of providing. Some current ways of low cost treatment of excrements and mortalities also give certain financial benefits. The other usual way of treatment is waste disposal in a manner that is not allowed. Although they are still in use, the continuous waste treatment practices of this kind are untenable, according to current and stricter legal regulations. Moreover, such methods of waste treatment cause huge damages to the health of people, animals and plants.

Thus, it is necessary to analyse on time the alternative solutions of dealing with excrements and mortalities from farms and animal waste from slaughterhouses, technical-technological and economic aspect.

Dealing with slaughterhouse waste

In slaughterhouses, there is a difference between treatments of two kinds of waste-solid (giblets, bones, feathers and leather) and waste waters. Slaughterhouses get rid of the bigger part of solid waste in the form of giblets and extremity remnants by using them for nutrition of domestic and wild animals. The owners of slaughterhouses feed animals with this waste on their own farms or they give it to other producers who come to slaughterhouses to pick up the waste. Therefore, this way of dealing with solid waste brings almost no costs slaughterhouses. Using the giblets in nutrition of animals, the owners of the slaughterhouses or other persons who come to slaughterhouses to pick up the waste (cattle breeders, peasants and hunters) can even realize some saving through the reduction of production costs, in the way they substitute animal waste for food and save the consumption of other kinds of fodder. Slaughterhouses mostly do not charge for giving the giblets away, because in that way they get rid of a significant part of solid waste, providing that a slaughterhouse would require the extra investments and regular operative expenses [4].

The other kind of solid waste in poultry slaughter houses-feathers, especially in mini-slaughter houses, is provided for by burial in the vicinity of slaughter house (with or without addition of certain disinfectants). This way of providing requires certain costs, but they are relatively low (digging and filling the holes, lime). In slaughter houses for large cattle, the leather, which has its economic price, appears as a side product and it has a treatment of non-waste. Leather is one of the sources of income which is realized through its sale to specialized buyers or leather manufacturers. The lamb leather has the same treatment.

Some slaughterhouses deal with feathers and other animal waste (bones, giblets) by taking them to public waste landfills by their own transport or by public utility services transport. In both cases, the additional expense is the supply of certain number of specific containers for waste disposal. Their number depends on the average daily quantity of solid waste and the frequency of waste transportation to the landfill. This kind of waste treatment also brings the shipping charges in the form of payment for the public utility services (per ton or flat rate) or the expenses of vehicles, fuel and money compensation for the workers who perform these jobs, in the case when slaughter houses do it independently. The height of these expenses depends on the price for waste transportation which is charged by local public utility services, and it depends on the distance between the slaughterhouse and the landfill to which the waste is disposed.

The compensation for slaughterhouses waste disposal to regional waste landfill in Ramići near Banjaluka is 100 KM/per ton, which does not include the shipping charges.

Dealing with mortality on farms

The side effects which accompany every cattle breeding production is animal deaths. Although animal dying depends on many factors and the number of dead animals vary, certain average scales of norms, fixed on the basis of other researches show that the average number of deaths per one production cycle are as follows:

- dairy cows 4,0%
- fattened beef cattle 1,5%

- fattened hogs 1,0%
- poultry (broilers) 5,5%

Current ways of providing for the mortality on farms as an example of a usual practice are: feeding of other animals, disposal to waste landfills, burial and incineration.

Feeding of domestic and wild animals with corpses of dead animals (especially the small ones), as a way of providing for mortality, is unacceptable. However, it is still wide-spread in domestic practice, first of all because it demands almost no expenses and it gives even certain benefits (saving of feeding expenses through substitution of a part of fodder).

Dead animals disposal to the existing waste landfills, is also an inadequate way of dealing with mortality, because none of the existing waste landfills has necessary infrastructure for that purpose. The owners of the firms mostly take away the dead animals on their own. The price of the dead animal disposal services in a regional waste landfill in Banjaluka is for a large cattle 20 KM/piece, and for small cattle 8 KM/piece. The compensation for dead cows disposal is 40 KM/ton, and for dead hogs 80-100 KM/ton. For example, in the USA, these costs approximatly amount to 105 USD/t excluding shipping charges. The dead animals disposal to waste landfills increases danger of disease spreading and this method is also limited due to the emission of methane into the atmosphere.

The dead animals burial is an acceptable way of this kind of waste disposal, provided that it is not risky from the viewpoint of hydrogeological characteristics of soil. Since the burial is performed in the vicinity of a farm, most often it does not cause special shipping charges. With cows, oxen and bulls, regarding the size of a farm, dying appears once a year or even rarely. In farms with 100 fattened hogs, it happens approximately twice a year. The norm for manual digging and filling the hole is around 3 working hours per m^3, i.e. for a hole of 4 m^3 or 2 holes of 2 m^3 around 12 hours, what costs around 50 KM a year. Dying of poultry appears more frequently, but the volume of the hole for their burial is smaller. In the case of weekly burial, it takes minimum 50 working hours a year and it costs around 250 KM/year.

In poultry raising farms, the incineration of dead animals is also suggested, especially at the initial stage of fattening, when the animals are smaller. The incineration is performed in the existing boilers or furnaces which are used for production of thermal energy. In the period of a year when the boilers and furnaces are used for heating the facilities, no extra energy is used for animal incineration.

Future practice

It is realistic to expect that introducing some new ways of dealing with animal waste is going to increase the previous costs to producers and manufacturers who are going to take those measures.

Of course, if there is an illegal way of dealing with, the costs of such way are none or low, but the dangers and the consequences for the health of people, animals and degradation of nature are severe or not measurable, and the costs of their elimination (external damages) are much higher than the costs for preventive waste treatment. In these cases the individual benefits are often present (saving of expenses) as well as social damages (additional costs for reclamation of consequences). The situation is defined as a situation of "moral hazard", the attempts of individuals to transfer their individual expenses to someone else, that is to make the wider community pay for their expenses.

In some cases, the substitution of some previously used way of the waste disposal with a new way can show that it is, from the economic viewpoint, more effective, because it leads to towards reducing of previous costs or to compensation of a par tor even all waste disposal costs with the help of realized benefits.

Taking into consideration the absence of specialized service firms in Bosnia Herzegovina, the future practical solutions in regard of providing for mortality of domestic animals should be directed towards the method of incineration, which appeared favourable for almost all species of animals as for as costs are concerned.

Dealing with solid and liquid excrements on farms

Future solutions to dealing with solid and liquid excrements on farms are as follows:

- Fertilization of agricultural land
- Production of biogas
- Waste disposal to places intended for such specific purposes.

Production of biogas

Some types of solid and liquid excrements have different energy values in terms of their usability for production of thermal and other energy. Animal excrements are a suitable raw material for the production of biogas, which presents an energent obtained from a restorable source. Therefore, it is interesting in the context of the word trends of substitution of non-restorable sources of energy with restorable.

Biogas can be used directly for production of thermal energy or for transformation of energy into electric power. Regarding the possibility of biogas production, daily abundance of some cattle heads is different: cows/bulls/oxen 1,32 m^3, hogs 0,87 m^3, and poultry 2,76 m^3.

The plants which produce electric power out of biogas are more complicated and more expensive. We come to a general conclusion that transforming thermal energy, obtained form biogas, into electric power, is not profitable, according to current prices of equipment and electric power, for the identified standard farms in

B&H. According to this conclusion, no further detailed economic analysis has been done.

Using a standard farm of 20 dairy cows for example, a quick check out confirmed the abovementioned hypothesis. This farm produces 300 tons of manure a year, market price of which is minimum 3.000 KM. Out of 300 tons of manure, it is possible to produce 9.600 m^2 biogas which transformed into electric power, gives max. 17.000 kwh a year. According to a market price of the electric power (the highest price of the electric power for households 0,129 KM/kwh), it means 2.200 KM reduction of expenses on the electric power not taken from the public distributor. On the other hand, the missed income from manure which was not sold, because it was used for production of biogas, is 3.000 KM. A negative net rest (the loss) between reduction of incomes and reduction of costs is 800 KM, although no additional costs of the plant for production of biogas and electric power form biogas have been calculated.

The incomes from the sale of animal excrements, which are far lower in other farms has been disregarded, and significant limitation for investments in the plant for production of electric power from biogas would be a minimum capacity of this plant. The biggest stnadard farm in the region (12.000 broilers) produces a quantity of biogas which requires the power of motor of not more than 10 kW. On the other hand, these farms have significant needs for electric power during the whole year (lighting and heating-during winter, and lighting and cooling-during summers). Only if, according to technical-technological aspect, the available quantities of biogas and the capacity of the plant for production of electric power from biogas could be coordinated, a more detailed financial analysis would show that the production would be justified from the viewpoint of the balance between costs and benefits.

The analysis of feasibility of the biogas usage on farms for production of thermal energy only, point to a problem of discontinuity in production and consumption of thermal energy on farms of cows and the farms of hogs. These farms have no need to heat the interior of the farm facilities, not even in winter periods, while households need to heat the residences in winter periods only.

For that reason, the only appropriate and useful is the production of biogas in poultry farms, where significant needs for thermal energy are present during the whole year. The fact gained by experience, shows that these farms for acquisition of energents (most often fire-wood) for heating the farm facilities, spend 3,000-6,000KM a year.

Analyzing other possibilities, it has been concluded that a direct incineration of animal excrements with production of thermal energy is a more acceptable option for smaller poultry farms than the production of thermal energy with the previously done transformation of poultry excrements into biogas. One more reason is a possibility of storing the excrements during summer periods, which is not possible with biogas.

Incineration

Incineration is performable in places where the waste appeared on farms or in special places - dog pounds. In other case, adequate transport should be provided (special vehicles) from the place of dying to the place of incineration.

Incineration on the farm itself is much simpler, but it has certain limits regarding coordination of the quantity of the waste and the frequency of its appearance with the capacity of incineration devices. Estimated quantities of dead animals taking into account the size of standard farms in the region point out that the incineration on the farm itself is economically justified on poultry farms only. One must take into account that incinerator is physically separated from the facilities where the animals and their food are. For other farms (for cows or hogs), it is economically justified to deal with dead animals in dog pound if there is some compensation payment by the farmer.

The quantity of dead animals on poultry farms is from 3 tons and more. Although the dispersion of waste is not the same throughout the year (mortality is higher in summer period), it appears on poultry farms on a daily basis and ranges approximately between 5 and 20 kilos a day. It means that incineration is not economical when it is done daily; however, dead animals should be gathered and kept in a cooling device, and the process of incineration should be performed when the minimal quantity is gathered in accordance with the capacity of the incinerator.

According to the case in the USA [3], the referent expenses for incineration of a dead poultry, depending on the type and age, range between 2,6 to 4,9 USD per libra, recalculated, that is 0,3-0,6 KM/kg. This means that only these costs would burden the price (of alive) broilers with 0,06 KM/piece. According to another source, these costs in Great Britain vary from 0,3 to 1,3 KM/kg.

The price of the work of the incinerator consists of investment (fixed) costs and operative (variable) costs. According to some available data, the price of a smaller incinerator (with the capacity of 225 kg) is in the USA 3.642 USD (with 1 chamber), that is, 4.642 USD (with 2 chambers), and the price of the smaller incinerator for poultry only, is about 2.000 USD. Their average usability age is 10 years.

A possible solution to reduction of costs is subvention to one part of these costs by the state, as it is the case in the neighbouring Montenegro. This way is justified in the case of existence of regional dog pounds, but it would probably be economically untenable if the costs of smaller incinerators located on farms would be subvented.

The other alternative is to deal with this waste at the place of generation (on farms) in combination with the

production of thermal energy in modified classical boilers, which has already been suggested.

Incineration with the production of heating energy

Our team suggests technical solution of combined burner that would serve at the same time for burning solid excerments of poultry and for burning dead animals. A constructional solution predicts an addition to a classic boiler for the production of heating energy that uses solid fuel (fire wood and coal). Investment expenses are analyzed in terms of the manner of taking care of the excrements. Regarding the dead animal disposal, the plant does not produce any additional costs during the greater part of a year, because the burning of the dead animal is synchronized with the boiler-burner activity for the heating of the interior of the poultry farm.

In the summer period (June-September), when there is no heating, the burner would activate only for the need of mortality disposal and in that case, its operation would cause some additional costs. In this period, dead animals would be collected in the cooling device (freezer) and burnt at the time when there are at least 50 kg of waste.

The price for the cooling device for preserving the animals on low temperature untill the moment of their burning would be around 500 KM, and minimal usability is 5 years. Burning would be performed once a week, with the expenditure of solid (fire wood), app.0,25 m^3 for one treatment of burning. The expenditure of solid fuel would be 40 KM/month, i.e. for four summer months app. 160 KM. Expenditure of electric energy for the freezer would be app. 50 kwh per month (6,5 KM a month).

During the three hour of burning a certain quantity of heating energy would be produced that would be used for water heating for the household as the most rational solution. This advantage has not been financially evaluated.

During the 4 summer months, the expenses of 1-2 tone of died chickens disposal (depending on the farm capacity) would be 140-280 KM/tone, i.e. they would be lower than with the method of classic burning.

Of course, this investment should be observed as a complementary to the investment in the boiler-burner of poultry excrements and it can only be realized under the specified expenses in that combination.

CONCLUSION

Based on the insight in the current situation concerning animal waste observed in Bosnia and Herzegovina, it can be said that the problem of waste has been inadequately dealt not only in B&H but in the neighboring countries as well. This situation is due to the lack of specific legal solutions that regulate waste issues in general, and animal waste as a subcategory of waste.

Current situation in the area of waste management represents an irretrievable loss both the environmental quality and economic and energy. Hence, it is important to educate the public to collect waste separately. Together with the education on the issue of waste, there should be education on the issue of waste influence on the environment and climatic changes.

Analyzing current situation, the simplest option for the dead animal and the slaughterhouse wastes seems incineration (there is no need for transport, extra rooms for processing, etc.). However, we do not exclude other ways of treating this waste (biogas production, processing in dog pounds, production of artificial fertilizers and food for pets etc.). Animal excrement would be easy to expand on soils respecting adequate measures concerning avoidance of overfertilization and contamination of underground and surface waters, but also the measures concerning better practice inside the farms. Likewise, there are some possible treatments that include biogas production and the incinerationof poultry litter i.e. its usage as fuel.

This paper gave the original suggestion of a concept of a device that could be used for burning. The essence is that instead of expensive liquid or gaseous fuel, the products from gasification of manure can be used (the mixture of sawdust of wood and animal excrement). Besides that, instead of classic incinerators there is a concept of combination of boilers and incinerators, that would use manure as fuel or in a case of slaughterhouse the dolt of wood. Apart from the solution to solid waste treatment, this suggestion increases the energy and ecological efficiency of farms or salughterhouses.

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BIOGRAPHY

Veljko Đukić was born in Zenica, BiH in 1957. He received the diploma in metallurgical engineer and the PhD degree in technical sciences from University of Banja Luka, Faculty of Mechanical Engineering. His main area of research is environmental protection. He has published 250 papers, five books and a number of studies and projects. He is currently working as an associate professor at the Faculty of Health Sciences of Pan - European University APEIRON Banja Luka.

MOGUĆNOSTI SPALJIVANJA ANIMALNOG OTPADA U BOSNI I HERCEGOVINI

Veljko Đukić

Rezime: *Predmet ovog rada je ekološki problem vezan za otpad koji nastaje na farmama i klaonicama. Problem otpada koji nastaje na farmama i klaonicama je očito veliki i evidentno je da Bosna i Hercegovina tome ne pristupa dovoljno.Pokazalo se da je incineracija jedan od najefikasnijih načina eliminisanja uginulih životinja i ostalog čvrstog otpada u savremenoj peradarskoj proizvodnji. Kao energent u procesu incineracije koristi se gasovito ili tečno gorivo. Glavna prednost predloženog koncepta leži u prijedlogu da se vlastiti otpad iskoristi kao primarni energent za incineraciju.*

Ključne riječi: animalni otpad, incineracija.