Aeration of cattle slurry at low or high temperature in finish climate.

Aération du lisier bovin à basse ou haute température en climat finlandais.

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Abstract

The farms can produce up to 2 500 m^3 of slurry in Finnish climate with 7-9 months indoor feeding period the slurry must be spread as fertilizer in May or June onto grass if the cultivation of cereal is unprofitable. The hygienization in an individual farm has been done as farm size scale both at low temperature or at higher temperature. The aeration at low temperature has been done as batch process of 200-700 m^3 beginning often from 0°C and ending to 20-30°C. The aeration at high temperature has been done as continuously operating processes at 30-45°C in aeration units of approximately 10 m^3 with theoretical retention time of 5 days. The hygienization has been improved although missfunctions have been found to happen. The hygienization at high temperature may have also some inhibitory effect against clostridia.

Keywords : *butyric acid, clostridia, enteric microorganisms, grassland, hygiene, manure*

Résumé

Une exploitation peut produire jusqu'à 2500 m^3 de lisier. Dans les conditions climatiques finlandaises, avec des périodes de stabulation de 7 à 9 mois, ce lisier sera épandu en mai ou juin, sur prairie si les cultures de céréales ne sont pas rentables. L'hygiénisation dans une ferme individuelle a été effectuée, en conditions grandeur réelle, à la fois à basse température et à température plus élevée. L'aération à basse température a été testée en processus discontinu (batch) de 200-700 m^3 commençant à 0°C et pour finir à 20-30°C. L'aération à température élevée a été effectuée en procédé de traitement continu à 30-45°C, dans des unités d'aération de l'ordre de 10 m^3 avec un temps de rétention nominal de 5 jours. L'hygiénisation a été améliorée en dépit de dysfonctionnements. L'hygiénisation à température élevée s'accompagne d'une inhibition de Clostridia.

Mots-clés : acide butyrique, clostridia, microorganismes entériques, prairie, hygiène, déjections.

1. Introduction

Cattle slurry formed during an indoor feeding period of 7-9 months should be utilized as fertilizer for grass because cereal production is very limited in Finnish cattle breeding areas. Grass with two harvests in a growth season is usually cultivated 3-4 years in the same plot. Thus about 1/3 or 1/4 of grassland area are renovated annually and, if slurry is used only on ploughed area, the farmers have difficulties to find place for slurry in spring or summer. The difficulty is still culminated by two facts: first the too early transport with heavy tractor and slurry wagon on agricultural fields, which are very soft in late May - early June after melting of snow, would cause long-lasting damages by compaction the soil and thus high reductions of yields and, secondly the farmers are very busy due to the short possible sowing time.

The farmers would like to spread slurry therefore also on growing grass after the first harvest on cut silage grass (in late June), if it would be possible and acceptable hygienically. The hygiene of treated slurry as grass fertilizer has been doubted due to butyric acid producing clostridia, because hard cheeses (mainly Swiss and Edam cheese) fermentation is very important for Finnish dairies and butyric acid producing clostridia destroy very easily the propionic acid fermentation. In addition, extra care for hygiene should be paid because many farms use own wells for drinking waters and sanitary waste waters are often led to slurry tanks and the enteric microorganisms may survive better in Finnish cold and rainy climate.

Hygienization of slurry was studied by aeration done either at low or high temperature with the aim to see if slurry could be used as fertilizer for grassland. Grass is then made for silage and this for hard cheese milk. The possibility to use anaerobic process was rejected because anaerobic process at mesophilic area may not reduce enteric microorganisms effectively (Martens et al., 1998). This may be because, the enteric microorganisms must have a special survival in anaerobic environment because their natural place, the intestinal channel, is highly anaerobic. In addition, anaerobic process at thermophilic area in farm size tanks would need much of extra heating because temperatures such as - 35^{o}C are usual during Finnish winter and very large tanks common to many farmers are not easy because Finnish farms often situate far from each others and transporting of slurry in winter (through ice and snow) would not be easy.

2. Materials and methods

Aeration processes have been tested in farm scale either as batch aerations in open tanks of 200-700m^3 the temperature beginning often from 0^{o}C and ending typically to 20-30^{o}C or as continuously operating processes at 30-50 ^{o}C in aeration units of about 10 m^3 with theoretical retention time of 5 days. Aerations were done by propeller aeration pumps 2.2-2.5 kW with axis lengths of about 2.5 m. If large aeration tanks were used, there were 1-3 pumps in a tank according to the size of tank. The pumps used were usually from Hesver, Finland or Pakola, Finland. The aerations at high temperature were done with the pumps of Hesver. A foam cutter (Hesver, Pakola or farm-own-constructions) about 0.1 kW has found to be needed. Most of the batch aerations at low temperature were carried by private farmers

(together more than 20 farms) and some by experimental farms. Batch aerations took usually 3-4 weeks. The continuous processes in thermoisolated and covered tanks were carried in two private farms. The slurry samples were send to laboratory with an express coach, so that the laboratory analysis work could be started in the same or next day.

A laboratory test at high temperature was done in water bath and using aquarium pump.

Hygienization has been followed by determination of DNA- and RNA-coliphages (*E. coli* ATCC 13706 and 15597 as hosts) according to the method of Adams (1959) with modification of Rajala-Mustonen and Heinonen-Tanski (1994), total coliforms were cultivated on m-ENDO-agarLES (Difco 0736-17-2; Finnish standard SFS 3016), faecal coliforms on mFC-agar (Difco, 0677-17-3; Finnish standard SFS 4088), enterococci on KF-streptococcus agar (Oxoid CM701) and colonies confirmed with 3 % H_2O_2 and on bile-aesculin-azid agar (Difco 0525-17; Finnish standard SFS 3014), sulphite reducing clostridia according to European Norm on media self-made (EN 26461) but incubated in Oxoid anaerobic jar and butyric acid producing clostridia with the method described by Jonsson (1989). The Finnish standard methods used base on international water hygiene methods.

3. Results

Hygienization in some aeration processes can be seen in the Table 1. The results of batch aeration describe one aeration process made in an experimental farm. In this case the temperature increased from 0 to 19°C. Many other aeration processes, where temperature increased from 0 to 20-30°C, would have given similar results (all data not shown) with 1-3 log reductions for non-sporulating microorganisms.

The continuous processes were followed during two winters in indoor feeding periods of the calendar year 1997. The results are geometric means of six or three determination times in farms 1 and 2, respectively. The temperatures in aeration tanks varied from 32 to 50 °C (farm 1) and from 25 to 33°C (farm 2). The flow in the farm 1 was much more laminar and more successful (fewer interruptions) than it was in the farm 2.

Microorganism	Batch aeration		Continuously processes			
			Farm 1		Farm 2	
	before	after	before	after	before	after
DNA-coliphages	$3.2\ 10^5$	$1.2\ 10^3$	130	13	$3.4\ 10^4$	$3.1\ 10^3$
RNA-coliphages	$2.6\ 10^5$	$2.3\ 10^3$	410	15	700	200
total coliforms	$2.7\ 10^5$	$9.3\ 10^3$	$7.0\ 10^4$	$1.7\ 10^3$	$1.2\ 10^6$	$4.6\ 10^4$
faecal coliforms	$3.2\ 10^4$	$2.1\ 10^3$	$1.2\ 10^5$	$1.6\ 10^3$	$1.0\ 10^6$	$5.1\ 10^3$
enterococci	$1.5\ 10^5$	$1.0\ 10^4$	$9.7\ 10^5$	$4.2\ 10^4$	$8.3\ 10^4$	$2.9\ 10^4$
SRC	$3.8\ 10^4$	$1.9\ 10^4$	$4.6\ 10^3$	$1.3\ 10^3$	$1.5\ 10^4$	$2.6\ 10^4$

BPC	$4.5\ 10^5$	$3.5\ 10^5$	$1.6\ 10^4$	$1.1\ 10^4$	$3.2\ 10^4$	$2.0\ 10^4$

Table 1.
The numbers of DNA- and RNA-coliphages, total coliforms, faecal coliforms, enterococci, sulphite reducing clostridial spores (SRC) and butyric acid producing clostridial spores (BPC) in three aeration processes.

Parameter	Aeration 1	Aeration 2
Temperature °C	50-59	56-66
Mean temp. °C	53.6	60.5
Redox potential mV	104	104
Clostridial density at the start	$8.6\ 10^4$	$6.8\ 10^4$
Clostridial density at the end	$3.6\ 10^4$	780

Table 2.
The number of butyric acid producing clostridial spores in 3 days´ laboratory test with temperatures and redox potential in two high-temperature aerations.

4. Discussion

The results suggest that farm scale aeration could improve the hygiene of slurry. Some risks caused by enteric, non-sporulating microorganisms can be reduced already if aeration is done at low temperature (less than 30°C) to save nitrogen - and aerations costs. The costs in this decade including capital for aeration apparatus and electricity at low temperature would be about 1.2 - 1.5 ECU/m^3 slurry (Haataja, 1998). The nitrogen losses typically have been about 10% (Leinonen *et al.*, 1998). Slurry could thus be used for fertilization of growing grass and spreading done either in spring for first harvest or in summer for second harvest. In both of these cases the sun radiation may still hygienize the grass during the growth.

The aeration at high temperature may destroy also spores of butyric acid producing clostridia so efficiently that the further contamination for silage or milk could be reducing. The temperature and other environmental factors destroying butyric acid producing clostridia would be important. The aeration at temperature, 56-66 °C, which reduced 2 log *Clostridium tyrobutyricum* and related bacteria should be still so low that according to the review of Mitcherlich and Marth (1984) it should not yet destroy the spores of this bacterial group. Therefore the reduction of this group was not only caused by warm temperature, although the heat has some effect as seen the results of Table 2. The high redox potential may also be an important factor at least for anaerobic clostridia. Therefore it might be important to study the combine effect of aeration, oxidative chemicals and temperature so that the theory for clostridial death could be better understand.

In practice the aeration of slurry at high temperature may be an alternative. The flow should be laminar and all bypasses avoided. Theoretically (calculated from BOD-reductions), more energy should be forming from heat than what is needed for electricity, but still this theory has not yet been vital. The heat formed could be utilized for instance for pre-heating drinking water of cows, which would allow the

cows to drink more and thus to give more milk. We should have more experience so that the missfunctions or surface cover could be avoided. The possible nitrogen losses from aeration could be reduced by using acid peat as biofilter. The theoretical retention time truly needed should also be further studied, especially if sanitary waste waters are also led to slurry tank.

5. Conclusion

5.1. It is possible to begin the aeration of cattle slurry in large storage tanks also in winter or early spring. The heat formed will melt the ice on the large slurry tank and heat the slurry up to 20-30^{o}C. The reductions of 90-99.9 % for many non-sporulating micro-organisms can be found. The spreading of aerated slurry would be more safe than that of non-aerated, fresh slurry for farmer's occupational health and for public health of the people living in neighbourhood.

5.2. The hygienization is still more effective if the aeration of slurry is done in small reactors as continuously operating process and the anaerobic butyric acid producing clostridia dangerous for hard cheese fermentation can also be controlled. The techniques is not yet ready and it would be very important to develop it, so that the flow is laminar in spite of the daily and weekly unevennesses of the load of slurry and the waste waters. This may be very important if the animal breeding units are coming larger as it may be in the future.

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