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Faecal microorganisms in run-off from cattle farming

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Abstract

Numbers of faecal indicator microbes (faecal coliforms, enterococci, sulphite-reducing clostridia and coliphages) were determined in run-off waters from cattle farms in 1998–2005. Water samples were collected from drain wells and open ditches adjacent to exercise yards and forested feedlots for cattle, a grass field with slurry applications and a pasture with buffer strips. The indicator numbers were the highest in run-off waters from asphalt exercise yards while the figures were even 100-fold smaller in waters from a bark covered yard. In the forested feedlots, where cattle were fed for the winter months or all the year round, the indicator numbers were as high as the ones in a grass field with slurry applications or a pasture. There was a severe risk of transporting pathogens to the environment, especially if run-off water from exercise yards and feedlots are only poorly purified and allowed to flow into ditches and watercourses. The existence of buffer strips between fields and watercourses may reduce the numbers of faecal microbes in surface run-off.

1. Introduction

Along with the recent growth in the size of cattle farms, problems with slurry management have increased in Finland. The act on animal welfare also provides that during the summer period dairy cows and heifers must be allowed to go to pasture or, failing this, that a space must be provided in such a way as to allow the animals to move around. This means that most cows will stay in pastures or in exercise yards in summer since July 2006. Leaks of slurry during storage, transport and spreading, and water flows from pastures and outdoor yards can act as vectors of disease transmission from agricultural areas. Microorganisms may enter surface water via overland flow pathways, by subsurface transfer routes in highly permeable soils or through artificial field drainage (Oliver *et al.* 2005). Here, observations were made of hygiene indicators in waters in the surroundings of cattle farms.

2. Materials and methods

This paper consist of 6 different studies on hygiene indicator levels in the surroundings of Finnish cattle farms. The study sites were located in North Ostrobothnia (Ruukki), South Savo (Juva), North Carelia (Tohmajärvi) and Häme, SW Finland (Jokioinen, Minkiö). Run-off water was sampled from

(1) exercise yards for cattle at Minkiö and Tohmajärvi (Uusi-Kämppä & Heinonen-Tanski 2000) and Juva (Puumala *et al*. 2002, Uusi-Kämppä *et al*. 2003),
(2) forested feedlots for cattle at Tohmajärvi (Uusi-Kämppä 2002, Puumala *et al*. 2002) and Ruukki (Puumal *et al*. 2002, Uusi-Kämppä *et al*. 2003),
(3) a grass field with slurry application at Jokioinen (Heinonen-Tanski & Uusi-Kämppä 2001) and
(4) a pasture with different buffer strips at Jokioinen (Uusi-Kämppä & Palojärvi 2006).

Dairy cows exercised for a few hours (4 hours used in calculations in Table 1) daily in the yards at Minkiö and Juva. During four summer months the cows grazed in pastures. Run-off samples were collected from wells situated in the exercise yards. Young cattle and suckler cows may sometimes be raised in forested feedlots. At Tohmajärvi, the suckler cows were fed for 7 winter months either in an asphalt feedlot or a forested lot. The cows with calves grazed in a pasture from June to September. At Ruukki, 10 bulls were raised in a forest area (1 ha) all the year round in 2000–2001. At Ruukki, the run-off water was collected from an open ditch adjacent to the feedlot, and at Tohmajärvi, percolation lysimeters installed into soil at a depth of 30–40 cm were used to collect percolation water (Uusi-Kämppä 2002). At Jokioinen, surface run-off samples were collected from a grassed land where cattle slurry was either broadcast or injected into clay soil 1996–2000 (Heinonen-Tanski & Uusi-Kämppä 2001). In the other study at Jokioinen, surface run-off samples were taken from an experimental pasture (Uusi-Kämppä & Palojärvi 2006) with either a 10-m wide grass buffer strip (GBS) or a vegetated buffer strip (VBS). Results from the pasture with GBS and VBS were compared with those from the pasture with a buffer grazed by cattle (gGBS). Two dairy cows and two heifers grazed for 28 days in the pasture (0.7 ha) in summer 2005. Surface and subsurface water to a depth of 30 cm flowed into a collector trench.

Water samples were filtered for faecal coliforms and enterococci through Millipore 0.45 um and for sulphite-reducing clostridia through Millipore 0.22 um filters. Faecal coliforms were then cultivated on mFC agar (Difco^{TM}) and confirmed by oxidase test (SFS 4088). Enterococci were cultivated on KF streptococcus agar (Difco), and colonies were confirmed with 3% H_2O_2 (SFS 3014). Sulphite-reducing clostridia were determined by EN 26461-2 (1993) and incubated in an Oxoid anaerobic jar. Water hygiene was further studied by determining somatic and RNA coliphages (*E. coli* ATCC 13706 and 15597 as hosts) according to the method of Grabow and Coubrough (1986), as modified by Rajala-Mustonen and Heinonen-Tanski (1992).

Table 1. The experimental treatments, size of experimental areas, livestock units per ha (LSU ha^{-1}), and livestock unit days per ha and year (LSU days ha^{-1} a^{-1}).

Treatment / Place	Size (m^2)	Cattle etc.	LSU (ha^{-1})	LSU day (ha^{-1} a^{-1})
1. Exercise yards / feedlots				
Minkiö (asphalt)	900	45 cows, 40 calves	770	31 000
Tohmaj. (asphalt) [1)]	570	8 suckler cows	140	29 000
Juva (asphalt) [2)]	500	1/3 of 100 cows	670	27 000
Juva (bark)[2)]	600	1/2 of 100 cows	830	50 000
Juva (sand)	500	Whole year, feeding	?	?
2. Forested feedlots				
Tohmajärvi	4 400	32 suckler cows	70	15 000
Ruukki	10 000	10 bulls	6	2 200
3. Grass, slurry				
Jokioinen		90 tn slurry ha^{-1}	4	1 400
4. Pasture, buffers				
Jokioinen	7 200	2 cows, 2 heifers	4	120

[1)] The asphalt lot with bark covered
[2)] The yard was divided into two parts: 1/3 of the cows stayed on the asphalt area while 2/3 preferred the bark surface
1 dairy cow or suckler cow = 1 SLU, 1 heifer or bull (< 2 years) = 0.6 SLU

3. Results and discussion

The results show that the highest numbers of hygiene indicators were detected in run-off water from exercise yards and feedlots made of asphalt and with the highest animal density (Table 1 and 2). The bark cover reduced the indicator numbers in run-off water in Tohmajärvi. Both in the forested feedlots and bark covered yard in Juva, the indicator numbers were smaller than in asphalt ones – maybe because the water was filtrated though the soil. The animal density was also smaller in forested lots because the soil surface becomes soggy if there are too many animals. The numbers of microorganisms in run-off waters from forested feedlots were as high as in surface run-off from the grass field with slurry applications and the pasture. There was a 10-m wide buffer strip between the field area and the water collection system in the both field experiments. In the pasture the numbers of hygiene indicators were the smallest in winter and in spring since there was no grazing in late autumn, winter and spring. After grazing and rainfalls the numbers again increased in summer.

4. Conclusions

Although the indicator numbers were less than they are in slurry or in wastewater influent, there was a severe risk of transfer of zoonotic pathogens to the environment, especially when surface run-off water from exercise yards are poorly purified and allowed to flow into ditches and watercourses as recreation waters. In the areas with high animal density there can be also risks that enteric microorganisms spread from one farm to the water are used for irrigation, milk production or other use in the other farm. More research is needed to establish the risk of pathogen transmission from livestock farms in different environments and seasons. Exercise yards and outdoor feedlots should be built so that the risks of pathogen transmission to waters can be controlled.

Table 2. Geometric means for numbers of faecal microorganisms in run-off waters from exercise yards, forested feedlots, a grass field with slurry applications and a pasture with different buffer strips. (n.a. = Not analysed)

		Number of microorganisms in 100 ml of run-off water as plaque-forming or colony formic units.					
Site	N	Coli-phages ATCC 13706	Coli-phages ATTC 15597	Sulfite-reducing clostridia	Total coliforms	Faecal coliforms	Entero-cocci
Exercise yards							
Minkiö a[1)]	1	1×10^4	2×10^3	1×10^4	7×10^6	7×10^6	3×10^6
Tohmaj. a[1)]	2	700	130	3×10^3	3×10^4	6×10^3	2×10^4
Juva a[2)]	4	1×10^6	1×10^5	5×10^3	4×10^6	5×10^6	4×10^6
Juva b[3)]	6	12	20	200	n.a.	7×10^4	5×10^3
Juva s[4)]	2	2×10^3	2×10^3	180	n.a.	3×10^5	3×10^4
Forested feedlots							
Tohmaj. s[1)]	3	2×10^4	20	250	1×10^4	1×10^4	4×10^3
Ruukki[2)]	4	n.a.	n.a.	44	2.5×10^3	220	n.a.
Slurry application							
Surface[5)]	3	3×10^3	100	2×10^3	2×10^4	900	5×10^3
Injection[5)]	3	110	1	69	6×10^3	400	500
Pasture[6)]							
gGBS	8			<0.5[7]	n.a.	2×10^4	9×10^3
GBS	7			<0.5[7]	n.a.	5×10^3	4×10^3
VBS	7			<0.5[7]	n.a.	3×10^4	6×10^3

[1)] Sampling June 7, 2000, (Uusi-Kämppä & Heinonen-Tanski 2000)
[2)] a = asphalt area (Apr 2001–Jun 2002), (Uusi-Kämppä *et al.* 2003)
[3)] b = bark covered area; sampling from drainage (Jun–Nov 2005), (Kuisma *et al*. Unpublished).
[4)] Sand area (Aug–Nov 2005) (Kuisma *et al*. Unpublished)
[5)] October 20, 1998; 4 days after slurry application + 38 mm rainfall (Heinonen-Tanski & Uusi-Kämppä 2001)
[6)] gGBS = grazed grass buffer strip, GBS = cut grass buffer strip, VBS = vegetated buffer strip; Aug–Nov 2005, (Uusi-Kämppä & Palojärvi 2006)
[7)] less than detection limit

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