A methodology for the sizing of slurry storages, and for measuring nutrient excretion on dairy farms

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Abstract
Proper sizing of slurry storage is the key to good nutrient management, and to avoid water pollution and soil compaction by machinery traffic in wet periods. On intensive dairy farms with high milk production, with the cattle indoor most of the time and with high stocking rates, there is a lot of slurry that must be properly stored. The slurry pit size must be calculated to store all faeces, urine, wastewater, bedding materials and rainfall during the period where slurry must not be applied to the soil, and therefore it is necessary to know the volume of each fraction and of the total slurry that is produced in each period. A methodology to measure the slurry production and nutrient excretion on dairy farms was developed. An equation is proposed to calculate the size of the slurry pit.

Material and methods
A device capable of acquiring, storing and reporting slurry level, rainfall, temperature and air humidity measurements from remote sensors was installed in a slurry pit on a commercial dairy farm.

The slurry pit was a rectangular prism of 133 m^2 made in concrete. The slurry level in the pit was measured with a sampling frequency of 20 times per hour by means of a ultrasonic sensor. A data logger stored the mean value of these 20 measurements. Rainfall was measured with a rain gauge and records stored in the data logger every hour.

The slurry pit stored only the manure produced by dairy cows. About forty seven dairy cows (mean annual) were housed all the time. The annual milk yield per cow was 9200 litres. The farm has 18.3 ha of arable land and therefore the number of dairy cows per ha is 2.57. Milking parlour waste water was measured with a water meter. Bedding material (kg) and number of cows housed daily was registered by the farmer.

Three slurry samples taken in July and December, 2005 and April, 2006, were analyzed. Slurry density was measured with a density meter. The

quantity of slurry produced by animals housed during any period of time was calculated from the following expression:

Total slurry production = Slurry level * slurry pit area.

The amount of slurry produced was calculated by cow and day obtaining the mean value from differents periods of time from January, 2005 to June, 2006. The amounts of faeces and urine produced were calculated by the expression:

Faeces + urine = slurry level* slurry pit area*slurry density - rainfall – milking parlour waste water – bedding material

Slurry nutrient content was determined from three different samples. The nutrients available per ha of arable land were calculated by multiplying the cow annual nutrient excretion (kg) by the number of dairy cows per ha of arable land.

Figure 1 shows the evolution of slurry level (height) in the pit from January, 2005 to June, 2006 and the periods of time taken into account when calculating the total amount of slurry produced. The periods were chosen between total or partial slurry emptyings.

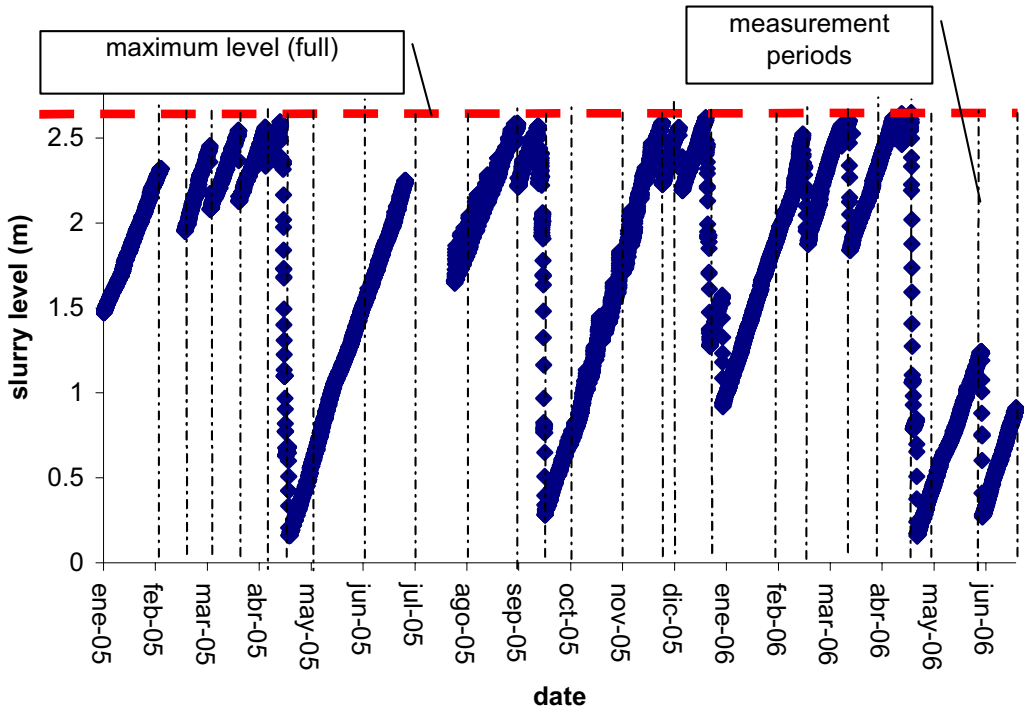

Figure 1. Slurry level (hourly measurement) in the pit, measured by means of an ultrasonic sensor.

Results and discussion

Table 1 shows the total slurry production and the production of the different components including faeces and urine, milking parlour waste water, rainfall and bedding material.

Table 1. Total slurry production and components

	mean	max	min	Std. Dev.	Var. coeffi.
Slurry total (litres/cow/day)	79.3	88.9	67.5	6.37	8.0
Rainfall (litres/cow/day)	5.7	17	0	4.7	82.5
Milk. parlour waste water (litres/cow/day)	16.1	18.3	14.1	1.23	7.6
Bedding material (kg/cow/day)	2.42	7	0.97	2.09	86.4
Faeces and urine (kg/cow/day)	57.7	64.6	50.4	5.49	9.5

Assuming a storage period of four months, the slurry pit size can be calculated by the following expression:

$V=S*h= 73,6*10^{-3} * M*30 + S*P*10^{-3}$,

where V = m^3 cow^{-1} ; S = slurry pit area (m^2); h = slurry pit height (m); $73.6*10^{-3}$ = m^3 cow^{-1} day^{-1} (without rainfall); M = number of months of storage; and P = rainfall (mm) for the period of autumn-winter storage. Considering the Galicia region rainfall zones (Cortizas et al., 2000), a slurry pit height of 2.5 m and 4 months of storage, the slurry sizing will vary from 10.8 to 13.6 m^3 cow^{-1} for uncovered pits, while for covered pits the sizing will be only 8,8 m^3 cow^{-1}.

With respect to nutrient excretion, Table 2 shows the composition of slurry (mean values of three slurry samples analysed for nutrient content).

Table 2. Slurry composition.

DM (%)	OM (g kg DM^{-1})	N (g kg DM^{-1})	P (g kg DM^{-1})	K (g kg DM^{-1})
10.4	70.3	35.5	6.9	38.3

Table 3 shows the annual organic matter and nutrient excretion per cow, and the amount of organic matter and nutrients available for recycling per ha of arable land.

Table 3. Annual excretion per cow, and nutrients available to recycle per ha of arable land.

	Organic Matter	N	P_2O_5	K_2O
Kg cow^{-1} $year^{-1}$	2312	117	52	151
Kg ha^{-1} $year^{-1}$	5469	276	123	357

References

Martínez Cortizas, A. y Pérez Alberti, A. (2000): Atlas Climático de Galicia. Consellería de Medio Ambiente, Xunta de Galicia. 210 pp.