FAO European Cooperative
Research Network

RAMIRAN

Recycling of Agricultural, Municipal and Industrial Residues in Agriculture

Network Coordinator: José Martinez, Cemagref, Rennes (France)

RAMIRAN 2002

Proceedings of the 10th International Conference of the RAMIRAN Network

General Theme: Hygiene Safety

Štrbské Pleso, High Tatras, Slovak Republic
May 14 - 18, 2002

Edited by Ján Venglovský and Gertruda Gréserová

ISBN 80-88985-68-4

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SAMPLING OF ANIMAL MANURE IN THE DUTCH MINERAL ACCOUNTING SYSTEM

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INTRODUCTION

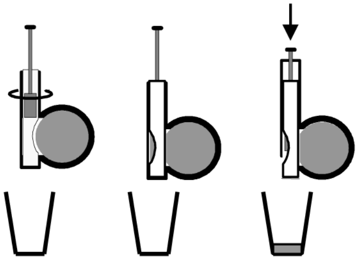
In the Netherlands the mineral accounting system (MINAS) was introduced as a legal instrument to balance the mineral input and output at farm level and thus prevent unacceptable loss into the environment. Since 1998 Dutch farmers are required to draw up an account of all mass flows containing nitrogen and phosphorus entering and leaving the farm. If total mineral input exceeds the output, taking unavoidable losses into account, farmers have to pay a levy. Animal manure represents an important entry at the mineral balance of livestock farms. The nitrogen and phosphorus output is quantified by sampling and weighing each individual load of manure leaving the farm. Sampling techniques for both liquid and solid manure had to be developed, considering the structure and (in)homogeneity of the material. Before the techniques were allowed to be used in MINAS they were tested on reliability and accuracy.
The objective of the experiments described in this paper was to quantify the accuracy in terms of reproducibility and bias of newly developed sampling methods, differing either in technique of sampling or in sampling protocol.

MATERIALS AND METHODS

General experimental design
Three sampling methods, two for slurry and one for solid manure, were tested in field experiments. The accuracy of the sampling methods was investigated by comparing their results with those obtained with a reference. The reference method chosen in each of the experiments represented a more eleborate sampling method with high accuracy. All test samples were analyzed on dry matter, total nitrogen and phosphorus, using standard methods for manure.

Sampling liquid manure
Transport tankers with a volume of approxemately 35 m^3 were used for testing the sampling of liquid manure; 30 loads of slurry from dairy cattle, pigs and poultry were sampled during loading from the hose, taking 5 subsamples to make one test sample. The subsamples (150 ml) were taken proportional to the loading weight. From each load two reference samples were taken. A reference sample was made from two vertical probes taken through two hatches on top of the transport tanker by using a sampling tube (L=2,5 m; Ø=0,05 m). Two techniques for sampling slurry during loading transport tankers were tested, the side tube and the plunger.

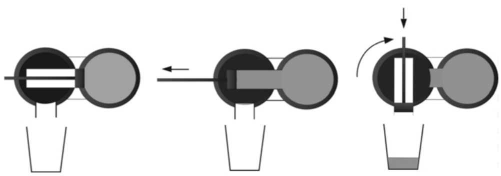
Figure 1 Side tube sampler



Side-tube concept

This device consists of a tube (Ø=0,05 m) hooked to the side of the slurry tube (Ø=0,15 m). The connecting part between both tubes is open. A second rotating (sampling) tube is fitted in the first. Part of the sampling tube is opened similar to the outside tube. By rotating the sampling tube a slurry sample is isolated from the slurry stream. The sampling tube is cleaned with a piston (Figure 1).

Figure 2 Plunger type sampler



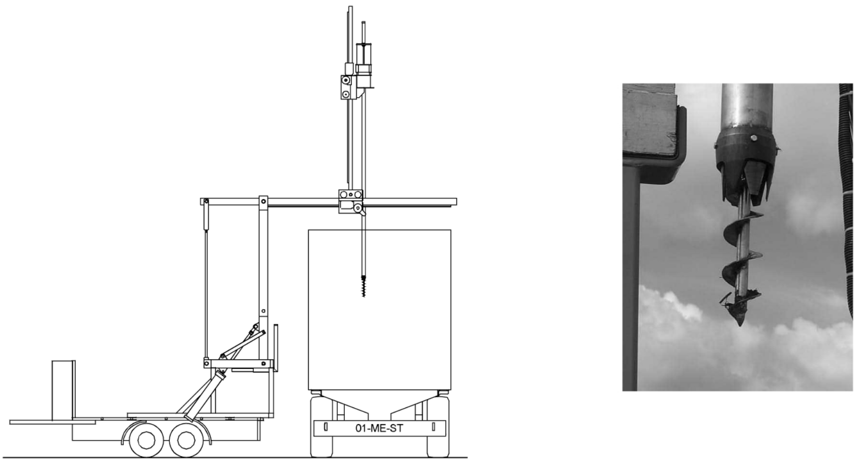
Plunger concept

The plunger type sampler consists of a sampling tube hooked at right angle to the slurry hose. By moving a plunger horizontally a sample is drawn from the slurry hose into the sample chamber. After rotating the sample chamber in vertical position the sample is isolated and collected in the sample pot (Figure 2).

Sampling solid manure

For sampling solid manure the cutting drill was developed. It consists of an auger fitted in two concetric tubes. The outside tube is fixed, the inside tube can rotate. At the bottom each tube is equipped with teeth. By rotating the inside tube a cutting action is created, which is necessary to cut straw and other fibrous material. The vertical movement and the auger are driven by electric motors. Figure 3 shows the set-up as used in the field test.
The cutting drill was tested in a field experiment for which 20 open containers (30 - 40 m^3) loaded with broiler and laying hen manure were used. From each container, spread over the surface of the container, 10 samples were taken.

Figure 3 Cutting drill as used in the field test.



Statistical analysis
The accuracy of sampling liquid manure with the side tube and the plunger type sampling device were assessed by estimating the size of the random error, here referred to as reproducibility. The reproducibility was determined by the variance of the random error:

$$\sigma^2\Delta = \sigma^2 M + 1/2\sigma^2 R \qquad (1)$$

where:
$\sigma^2\Delta$ is the variance of the differences between method M and the reference method; $\sigma^2 M$ the variance of the random error of sampling method M; $\sigma^2 R$ the variance of the random error of the reference method. By calculating within each set of data $s^2\Delta$ and s^2R, being the estimators of $\sigma^2\Delta$ and $\sigma^2 R$, it was possible to derive the estimator s^2M from $s^2\Delta - 1/2s^2R$. For each set, 95%-confidence intervals were constructed from the estimated deviation sM and t-values based on n-1 degrees of freedom (n is the number of loads).
The reproducibility of sampling solid manure with the cutting drill was assessed by calculating the variance within each load and subsequently calculating the mean of variances of all loads. The standard deviation (sd), assessed after log transformation, corresponds with the coefficient of variation (CV) on the original scale and is presented as a relative error. The deviation thus found represents the error of sampling if taking one sample per load. However, if several samples from one load are collected and combined into one mixed sample, the error is getting smaller:

$$s = sd/\sqrt{n} \qquad (2)$$

where:
s is the error of a mixed sample and n is the number of subsamples. The 95%-confidence interval around a measured value x (concentration DM, N or P) has the boundaries $x \pm t*s$, where t is dependent on the number of subsamples.
The variance of scattering in the measured concentrations (sd^2) is the sum of variance of sampling dispersion (s_b^2) and the variance of analyzing dispersion (s_a^2):

$$sd^2 = s_b^2 + s_a^2 \qquad (3)$$

Thus, for determining the accuracy of a mixed sample made from n subsamples the following relationship is valid:

$$s^2 = s_b^2/n + s_a^2 \qquad (4)$$

In determining the accuracy of the cutting drill it was assumed that the sampling is unbiased. This assumption is justified on basis of results of earlier tests with a predecessor of the cutting drill.

RESULTS

In Table 1 the mean composition of the sampled loads in each experiment is given.

Table 1 Mean composition (and standard deviation) of loads of manure used in the experiments on testing sampling methods (in g/kg).

Experiment	Manure type	DM	N total	P
Side tube	Pig slurry (n=30)	86 (27)	7.3 (2.0)	1.7 (0.5)
	Pig slurry (n=26)*	94 (17)	7.9 (1.3)	1.8 (0.4)
	Cow slurry (n=30)	75 (21)	4.7 (0.9)	0.6 (0.2)
	Poultry slurry (n=30)	146 (21)	10.4 (1.0)	2.6 (0.6)
Plunger	Animal slurry (n=46)	72 (33)	5.2 (2.4)	1.0 (0.7)
Cutting drill	Poultry solid manure (n=20)	504 (21)	19.0 (0.9)	6.1 (3.5)

* Four loads of pig slurry with lowest DM content originating from sows were left out of consideration. The concerning loads showed relative large differences with the reference. For this reason the reproducibility of the side tube was determined with and without these loads.

In Table 2 the level of reproducibility of the tested sampling techniques for and per component analyzed is given.

Table 2 Reproducibility of sampling with the side tube, plunger and cutting drill type sampler, represented as the relative deviation (95%- confidence interval) from the reference (in %).

Sampler	Manure type	DM	N total	P
Side tube	Pig slurry	13.0	7.5	21.5
	Pig slurry *	5.5	3.0	6.5
	Cow slurry	15.0	7.5	16.0
	Poultry slurry	7.5	6.0	12.0
Plunger	Animal slurry	10.3	3.5	17.0
Cutting drill	Poultry solid manure	19.8	23.2	25.8

* Comment idem Table 1.

Table 2 shows differences in sampling error between the sampler type, type of manure and components analyzed. The sampling error for pig slurry with the side tube sampler decreases substantially when 4 loads of sow slurry are left aside. Obviously these loads have more than proportional (negative) effect on the sampling error. For the sampling of cow slurry we found larger errors than for pig and poultry slurry and for phosphorus the error is larger than for nitrogen and dry matter. On the whole sampling of animal slurry with the side tube shows similar reproducibility as the plunger.
The given sampling errors for the cutting drill are valid if one sample from a load of solid manure is taken. Figure 4 shows the relationship between the sampling error and the number of subsamples from one load; the subsamples are combined into one mixed sample.

Figure 4 Relative error of sampling a load of solid manure with the cutting drill in relation to the number of subsamples for DM, N and P.

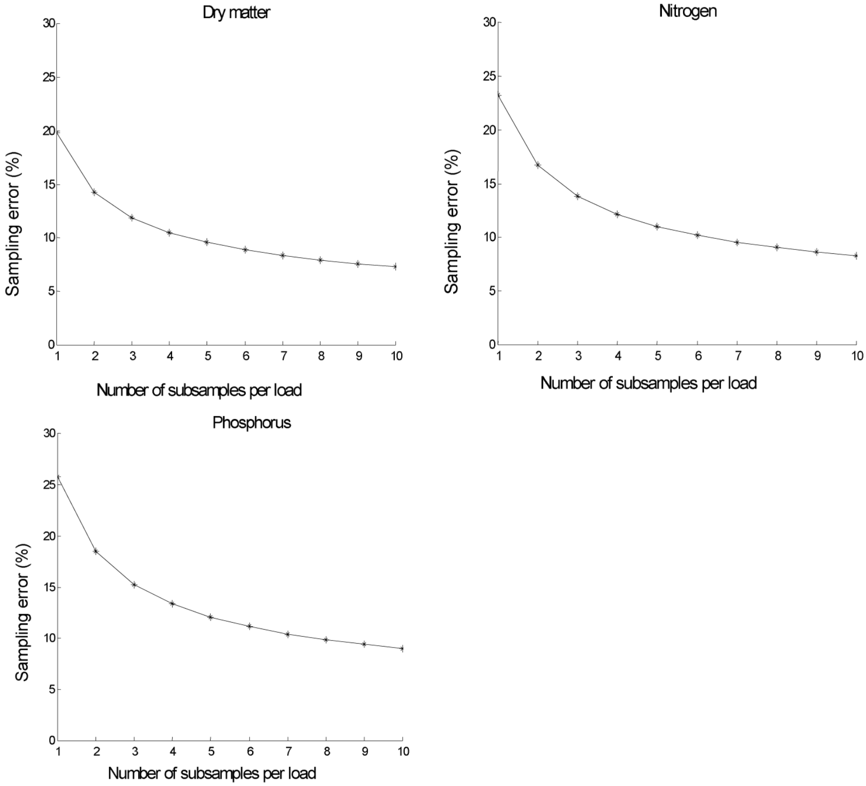


Figure 4 shows that the level of accuracy of the cutting drill is increasing with the number of subsamples per load. This is because the sampling error decreases. The analyzing error is constant (one sample is analyzed). The relative contribution of the analyzing error is becoming larger with the number of subsamples, according to equation (4). The contribution of each extra subsample to the increase of the accuracy is getting less.

CONCLUSION

The side tube and plunger type sampler for loads of liquid manure are comparible in terms of accuracy of sampling. The accuracy of sampling loads of solid manure with the cutting drill is related to the number of subsamples; taking more than 6 subsamples is hardly profitable. All sampling methods tested show acceptable degrees of accuracy to use in MINAS.