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# Towards more environmental safety from silage clamps

*Fermentation and run-off effluents from silage clamps represent a high environment damage potential although they are basically avoidable through building and procedural actions. The concentration of organic components in contaminated precipitation water indicates that the environmental-damaging potential of this material correlates positively with the quality of the silage material remaining in the clamp and negatively with the amount of precipitation.*

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## Keywords

Horizontal silos, silage effluents, environmental risk, silo construction

In Middle Europe, the use of unroofed silage clamps in the provision of forage for ruminants is widespread. However, this method of silage storage has been increasingly criticised in the last years because of the potential damage to water and soil through resultant silage effluent. The current extent of scientific knowledge applying this problem area, including appropriate constructional and procedural measures, is still unsatisfactory and is being extended through field and laboratory experiments.

### Methods

With a large-scale mechanised experimental site consisting of a „Traunsteiner" silage clamp (~275 $m^3$), four prefabricated clamps (each ~175 $m^3$) and a silage ground plate (~250 $m^3$), the silage effluent fractions from fermentation and run-off as well as contaminated precipitation water were registered in separate periods and their environmental-endangering potential determined through spot check methods with analysis of the total effect parameters of biochemical oxygen demand in five days ($BOD_5$) according to DIN 38409. The experiments were carried out over more than three years under field conditions with 19 ensiling and clamp-depletion campaigns. Alongside this, the effluent content of soluble organic carbon, total nitrogen and dry matter, as well as the pH levels, were investigated [1,2].

- Fermentation effluent: cell water including possible absorption solutions from silages under around 30% dry matter content
- Run-off effluent: foreign water after its passage through ensiled forage
- Contaminated precipitation: precipitation water containing silage-sourced materials

In that a factorial experimental plant with the required repetitions was not realisable under field conditions because of the enormous expense and effort involved, the problem area of contaminated precipitation water was additionally studied in-depth through model-type operations on a laboratory scale. For this, two grass silages, one maize silage and a sugar beet leaf silage, all of determined quality, were wetted via precipitation simulator with defined precipitation intensities of 3, 5, 10 and 20 mm/h and the water samples collected over the period investigated analogue to the field trials [2].

### Fermentation effluent is avoidable...

The field trials confirm findings up until now, that fermentation effluent represents the highest $BOD_5$ content of all silage effluents with an average 51400 mg $O_2$/l. (*table 1*) [1,2]. The results confirm the dominating influence, even when not alone decisive, that the dry matter content (T) of the original material has on the production and quality of the fermentation effluent. In the trials, silage with a T-content of over 290 g/kg produced no fermentation effluent. In general, the different estimation procedures in the literature lead to an over-estimation for forecasted fermented effluent production compared with that measured, in particular this leads to over-estimations concerning very wet primary forage material of under 170 g T/kg. Additionally, the results documented a production of fermentation effluent that continued long after the periods given in the literature. Because of the quality differences in the primary forage materials and the silage resulting from them, the danger potential of fermentation effluent is strongly variable

*Table 1: Average $BOD_5$ contents of various silage effluent fractions*

| Factor | $BOD_5$ content [mg $O_2$/l] | Observation |
|---|---|---|
| Fermentation effluent | 51400 (20582) | Avoidable |
| Run-off effluent | 34650 (22342) | Avoidable |
| Contaminated precipitation water | 1730 (1568) | Unavoidable |

Standard deviation s in brackets

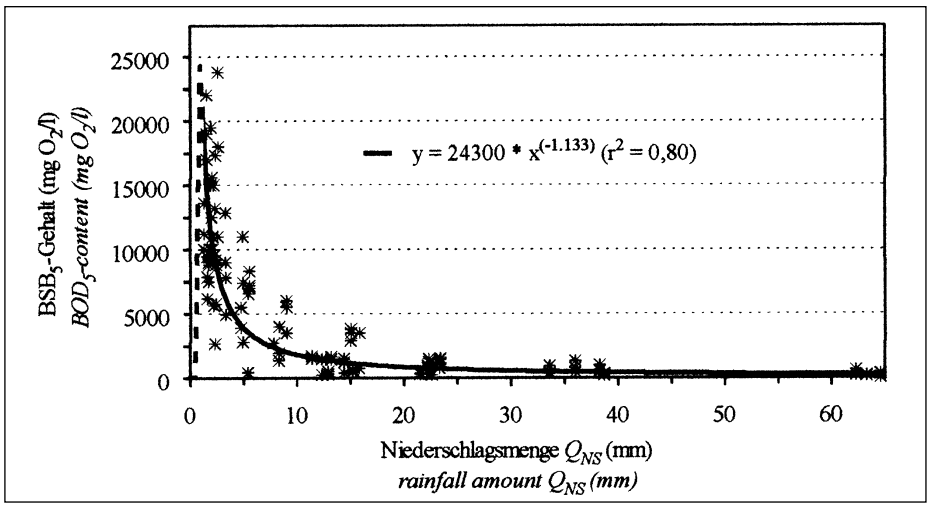


*Fig. 1: $BOD_5$-contents and estimated regression function of contaminated precipitation water depending on the amount of rainfall (silage mass 1.3 kg/m²)*

and this is expressed by the high standard deviation of the average values given in *table 1*.

#### .....run-off effluent too

For the first time, the silage experimental set-up allowed identification of the decisive causes behind the production of run-off effluent. The average environmental pollution potential from this effluent lay at an unexpectedly high level with $BOD_5$ contents of 34650 mg $O_2$/l and was influenced through the number and types of precipitation occurrences, the exposed and unprotected site of the storage area and the quality of the ensiled materials. (*table 1*). Thus, the run-off effluent $BOD_5$ content from wet silage lay at an average 15300 mg $O_2$/l, that produced from drier material was able, with 54000 mg $O_2$/l, to reach an environmental pollution potential of a level similar to fermentation effluent. Where the forage is completely covered, most importantly at the joining point of forage and clamp walls or floorpan, the production of run-off effluent is avoidable.

#### Contaminated precipitation water is system-dependant

The information on the degree of organic stress from contaminated precipitation water gained from the silage clamp experiments demonstrated at the same time its pollution potential. Although the pollution results lie under those from fermentation and run-off effluents they are still of importance, however, in that this effluent fraction is unavoidable in clamps. Even where the silage clamp area is free of silage and brushed absolutely clean there occurred a level of contaminated precipitation water which, with an average 1730 mg $O_2$/l demonstrated a $BOD_5$ content that was around five to six times the level of domestic sewage – while the large distribution breadth of the findings (table 1) is traceable to unsystematic environmental conditions in the field experiments.

#### Silage remainders in the clamp heighten the $BOD_5$ content in effluent

Through the sprinkling of various silages with water, it was possible to investigate the mechanisms of metabolism under laboratory conditions.

In addition to the quantity, the quality (crude fibre content) of exposed silage remains showed an influence on the production of contaminated precipitation water. In *figure 1* the effluent $BOD_5$ content from various types of material is listed against the applied amount of precipitation.

The progress of the effluent $BOD_5$ value measured during the trial period in connection with the amount of precipitation can thus be characterised through a reducing potency function (fig. 1). The influence of the intensity of the precipitation on the $BOD_5$ value of contaminated precipitation water is hardly deducible from the individual observations. Much more efficient as a measure for determining the level of the organic material carried in the effluent was the specific content of water-soluble material in the silage. A higher proportion of transport substances within the silage reduced, an expansion of the surface area through mechanical treatments, speeded-up, the washing-out of material. By far the largest proportion of the organic material was carried into the effluent by small precipitation amounts of up to 5 mm.

#### Conclusions

Through constructional and procedural improvements, such as the matching of the clamp side walls to the form of the silage heap, effective drainage systems for leading-off precipitation water from the clamp covering and the ground plate, ensiling of material with a T-content of over 300 g/kg and also though careful withdrawal of the forage from the clamp face, mean the negative effects on the environment from silage clamps without roofing can to a large extent be avoided.

The storage of silage in clamps without ground plates, especially where there is no annual change of site is, according to the findings of the work on contaminated precipitation water reported here, not advisable.

## Literature

[1] *Kahlstatt, J., G. Wendl* und *H. Pirkelmann*: Abwässer von Flachsiloanlagen – Quantitative und qualitative Erfassung. Landtechnik 51 (1996), H. 1, S. 26 – 27

[2] *Kahlstatt, J*: Feld- und Laborversuche zum Auftreten von Silageabwässern aus Flachsiloanlagen unter besonderer Berücksichtigung der Umweltverträglichkeit. Dissertation, TU-München, 1999, 198 S.