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Storage of Chipped Field Wood

Losses and Mould Fungi Infestation

Storing freshly harvested wood chips in non-ventilated piles results in mould fungi development, resulting in considerable dry-matter losses after only few weeks and furthermore in an occupational hygiene risk. The dominant effect of field wood chip length on temperature development and drying, as well on mould fungi growth and mass and energy losses in long-term storage was proven and quantified in semi-technical and large scale experiments.

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Keywords

Wood chips, storage, loss, mould fungi, short rotation crops

The demand for wood chips has increased considerably in recent years. In order to meet demands on a long term basis, the cultivation of fast growing trees such as poplars and willows on agricultural areas is an obvious choice. The bulk line is the favoured harvesting method used for this field wood. In this method, the trees are felled and chipped in one operation. However, the storability of wood chips produced in this way is limited due to the high moisture content of 50 to 60 % w.b. In bulk storage, micro organisms especially mould cause high temperatures and an economically relevant loss in mass and energy within a few days [1]. The development of mould can also pose a serious hazard to working hygiene conditions [2].

Materials and Methods

For the storage experiments, felled 2 to 8 year old short rotation poplars and willows with a breast height diameter of 120 mm as well as pine were used. The moisture content was at 50 to 60% w.b. The wood chips were produced using four different chippers and had an average length (median value) of 16 to 156 mm (HS 16 to HS 156), corresponding to an average sieve perforation width of about 10 to 80 mm.

It was stored in the following containers or piles:

- Storage silos of 1.5 m^3, consisting of cylindrical rigid PU foam bodies (h = 2.0 m) with rain protection.
- Storage boxes of 10 m^3, consisting of rectangular arranged thermally insulated concrete slabs (h = 2.5 m) with rain protection.
- Storage piles of 18 m^3 to 2000 m^3, consisting of freely placed triangular stacks (h = 3...6 m) with and without rain protection (*Fig. 1*).

Temperature measurements were taken at 4 to 5 levels with embedded PT 100 temperature sensors and mini data loggers or with 1.20 m long electronic stack thermometers. Losses in dry matter were determined with the help of balance bags. According to the type of storage (silo, box, piles), 6 to 66 balance bags in all were arranged at 3 to 6 levels.

The number of mould fungi was determined using the indirect method. Here, 20 g of germ reduced chopped wood (~ 1 cm^3) was added to 180 ml of Ringer solution, diluted in a decade thinning row and put with a spatula either onto nutrient plates of malt extract agar or onto DG 18 agar. The DG 18 plates are analysed after 7 days incubation at 20 °C (mesophilic fungi) and the malt extract plates after 1 to 2 days incubation at 37 °C (thermophilic fungi). Morphologically differing colonies were identified [1]. Measurement of the spore concentration of the mould fungi in the air was carried out in accordance with the technical standard for biological working substances TRBA 430 [3].

The course of temperature and drying

The average temperature in the wood chip piles shows a characteristic course. Directly after storage it increases rapidly and reaches its maximum value of 60 °C after 10 to 30 (50) days. This value is to a large extent determined by the bulk volume, surface area, surrounding temperature and particularly by the size of the wood chips. After 100 to 150 days (end of January) the temperature reaches a clearly lower value and after that successively decreases to the ambient temperature [1]. The reason for the increase in temperature is the heat produced from the respiration of the sap wood cells which are still alive (< 40 °C), and due to the activities of micro organisms, particularly of the fungi (< 60 °C) and bacteria (< 70 °C).

Fig. 1: 70 m^3 pile at the edge of a poplar field

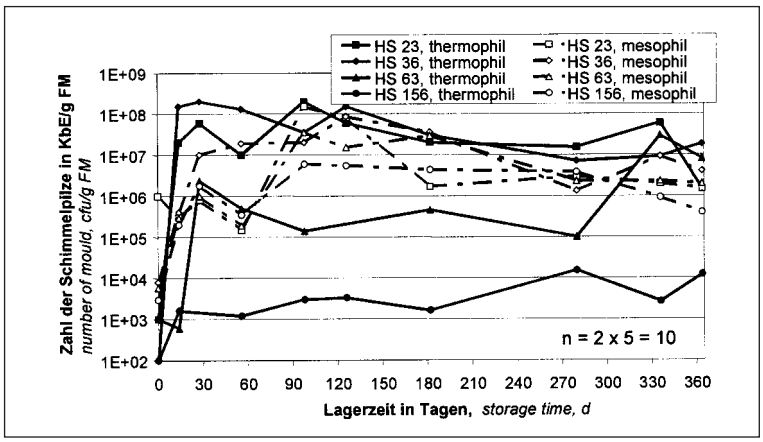

Fig. 2: Mould development in 10 m³ piles of poplar chips of different length

Drying of the wood chips does not only depend on the temperature of the pile but also on the initial moisture content and the size of the chips. Drying is to a large extent complete after 100 to 150 days for fine as well as for coarse chips and even for whole trees (Ø < 80 mm), thereby with the end of the high temperature phase in the piles. As a result of the high flow resistance, and the high temperature and the condensation produced by this under the surface of the pile, fine chips hardly dry to less than 30%w.b. in the course of one year. Even middle chips (31...50 mm) seldom fall below this value. Only chips with a length of > 60 mm reach a moisture content of less than 30 % w.b.[1].

Mould fungi development and spore emission

The mould development shows close interactions with the temperature in the wood chip piles. Here, the number of fungi increases analogue to the temperature in the first 10 to 30 (100) days to the maximum value of about 103 to 108 KbE/g FM. It remains more or less constant after that in contrast to the temperature and decreases mostly only slightly (*Fig. 2*). This discrepancy could possibly be due to the fungi spores characteristic of not dying in unsuitable conditions, but of remaining in a state of rest for longer periods of time.

The number of mesophilic mould fungi in the range of 10 °C to 50 °C is not or only slightly dependent on the average pile temperature [1]. This means that in the storage of wood chips, the possibilities of influencing the development of mesophilic mould fungi is limited. However, the increased occurrence of thermophilics, thereby mainly the potentially human pathogenic types, can be prevented by avoiding temperatures over the average of 20 °C or maximum 35 °C.

The spread of spores is dependent on numerous factors, especially on the mould infestation and air speed [2]. The spore concentration in the air, determined at different distances and at different times in undisturbed wood chip piles lies within the range of 10^1 to 10^4 KbE/m³ air. The measured values in the surrounding air are thereby exceeded by about one or two powers of ten.

If the structure of the pile is disturbed, as is necessary in mechanically depositing and re-depositing the wood chips for instance, the spore concentration in the air can reach values of 10^5 to 10^8 KbE/m³ for short time periods, depending on the distance. The technical control value (TKW) for biological waste treatment plants of $5 \cdot 10^4$ KbE/m³ for mesophilic mould fungi, for example, is therefore exceeded [4].

Dry mass and energy loss

In the storage of wood chips losses occur which can mainly be attributed to mould fungi. The results show that the average dry mass loss in unventilated piles of freshly harvested wood chips is at 10 to 30% per annum. Locally, in particular in the peripheral zones, maximum values of over 40% p.a. can even occur. However, a statistically significant correlation between the infestation of mould fungi and the loss in dry matter is not deducible [1].

In practice, it is not so much the loss in dry matter but far more the loss in technically usable energy which is decisive. Insofar as condensing boiler technology is not used, this results from the dry mass and moisture losses as well as the change in the lower heating value which, however, only changes slightly in long term storage [5]. For fine chips HS 16, the energy loss is almost identical to the loss in dry matter and is at 20 to 30% p.a. For coarse chips > HS 120, it lies within the range of - 5% to + 5% p.a. (*Fig. 3*), due to the small loss in dry matter and due to the low moisture content.

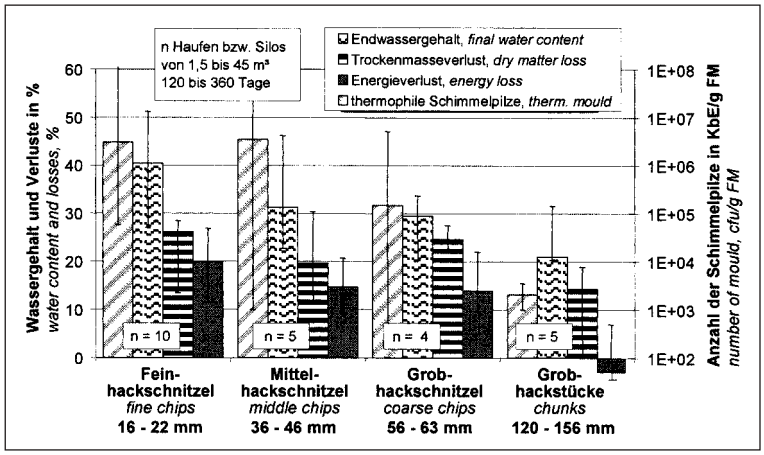

Fig. 3: Mould fungi, end moisture content and losses during storage of chips and chunks from poplar in unventilated piles

Summary and prospects

The loss in dry matter and mould fungi development cannot be completely avoided during storage of wood chips in unventilated piles, but the energy loss and the formation of fungi species hazardous to health can be reduced to a justifiable minimum by the choice of an appropriate wood chip length. The average length should be at least 100 mm.

After one year in storage, the average moisture content of the piles is between 20% w. b. for coarse chips and up to 50% w. b. for fine chips. Rain protection can considerably improve drying and reduce the formation of mould fungi and losses, particularly in the case of fine and middle chips. A split floor or ventilation canal also improves storage conditions, is however only effective for chip lengths of about 30 mm or longer.

Further investigations should incorporate other types of wood. Fungi spore measurements should also be made in commercial plants in order to develop dimensioning principles for the sizing of wood chips for storage.

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