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TYPHA CULTIVATION IN AGRICULTURE

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Abstract

The large-scale use of typha plants as a building material allows to support numerous aims of environmental policy at the same time. The cultivation of typha will provide environmental benefits with regard to stabilization and renaturation of re-wetted fenlands. By re-wetting dried fens, typha cultivation will absorb carbon dioxide instead of release large quantities of CO_2. In Germany, the share of emission from dried fenland areas is about 4 % of the total carbon dioxide emission. From the environmental point of view, an additional advantage is given by the fact that cultivated typha crops provide an ecological niche for numerous animal species worthy of protection. At the same time, typha cultivation also contributes to water protection, as the cattail plants purify large quantities of polluted surface waters. Besides accessing additional employment opportunities through the cultivation of typha and (if possible) own production of typha boards, farmers can also considerably improve their image by supporting measures for the protection of the environment, for nature conservation, and flood control. At present, the market for building materials does not offer any other product comparable to the magnesite-based typha boards. This building material is particularly distinguished by the unique combination of load-bearing capacity and insulating performance. The market potential of the currently available magnesite-based typha panels is therefore already very high, as the panels are also fully compostable and the whole process ensures a high level of sustainability (in connection with the cultivation of the raw material for the panel production). In view of all these advantages, the product promises to succeed in overtaking considerable market shares, both nationally and internationally. Currently, there is no comparable product which combines that many benefits.

Keywords: New building material, good insulating and load-bearing properties, cultivation/ industrial utilisation of cattail plants.

1 TYPHA PLANTS PROPERTIES AND POSSIBILITIES FOR AGRICULTURAL USES

Cattail is a perennial wetland plant, 10 - 15 species of which are spread all over the world. Cultivation focusses on two species that are very common in Europe, namely typha angustifolia (narrowleaf cattail) and typha latifolia (broadleaf cattail). In our latitudes, both species form very dense stands with plants of up to 3 metres in height. As the wild plant naturally grows in monocultures, problems like soil fatigue are not expected to arise in cultivated populations. Since established cattail plants spread rapidly by lateral rhizomes generated at the base of the leaves, an almost closed population will develop within 6 months even with large plant interspace (0.5 to 2 plants per square metre), if provided boundary conditions are favourable. Once the population has been established, vegetative reproduction will occur by stolons.
Assuming undisturbed distribution, a parent plant may produce up to 35 daughter plants per season and thus colonize 1–2 m², approximately. Particularly narrowleaf cattail (*typha angustifolia*), which is especially suited for the production of magnesite based typha panels, forms very dense populations with up to 120 shoots per square metre.

Cattail plants will flourish on wet habitats that offer medium to rich supply of nutrients and preferably full exposure to sunlight. Typha angustifolia prefers permanently flooded habitats, while *typha latifolia* prefers areas with water-level fluctuations. Cattail plants have a good tolerance of high nutrient concentrations and continued excessive supply of nutrients. Typha populations are robust, natural monocultures, which yield 15–20 t of dry matter per hectare each year (about 150–250 m³ of building material). This corresponds to four or five times the crop yielded by native coniferous forests. The practicability of typha cultivation has already been demonstrated by the project entitled 'Rohrkolbenanbau in Niedermooren' [Cultivation of typha in fens] managed by the Department of Landscape Ecology at TU Munich which was funded by the German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt BDU) (Pfadenhauer & Heinz 2001).

Due to the high polyphenol content in typha, cattail plants are weather resistant and biologically resistant to fungal and insect infestations, hence there is no need to use pesticides or insecticides to maintain crop production. The only requirement is a nutrient-rich soil that will supply sufficient minerals for the typha plant. Typha is one of the few cultivated plants to enable a stabilising use of fens that is both close to nature and appropriate to the location. This means that previously unprofitable land can be developed for economic purposes. This also means that typha cultivation does not conflict with food production, unlike most other insulating or building products made from natural materials. Another crucial advantage of typha cultivation results from the fact that substantial infestation by pests and plant diseases need not to be feared, which is why natural monocultures of typha crops are encountered all over the world. Due to their outstanding productivity, cattail plants are thus predestined to be used as a raw material for industrial applications.

Figure 1. Typha sprout with leaves resembling a fan

Figure 2. Typha stand at 'Donaumoos' fen, Germany (photos: TU Munich)

A precondition for the optimal use of the plant is winter harvesting, because in the winter time the sugar that is contained in the leaves and the starches will be shifted to the rhizomes (botanic term for a stem system that grows mainly in the underground or slightly above the soil), and the leaves will be dry. Besides, this will also facilitate harvesting, as the area can either be dried up or - due to the freezing ground - harvesting vehicles will be able to drive on the crop area, which would allow the use of simple bar mowers. Since the mass of typha leaves is very lightweight (approx. 60 kg/m³), it would be environmentally irrational to transport the material across large distances. For instance, a transport from Romania (where the raw material grows in natural stands) is more expensive than the material itself.

2. RELEVANCE FOR THE PROTECTION OF THE ENVIRONMENT

The large-scale use of typha plants allows to support many aims of environmental policy at the same time. The wet use of fens ensures the natural functions of peatland, like retention of nutrients and water. Also, the important function of peatlands regarding soil carbon sequestration is restored; the fen provides a suitable, sustainable alternative land use for the future. The cultivation of typha will provide environmental benefits with regard to stabilization and renaturation of re-wetted fenlands. By re-wetting dried fens, typha cultivation will absorb carbon dioxide instead of release large quantities of CO_2. In Germany, the share of dried fenland areas in carbon dioxide emission is approximately 4% of the total emission ((Faulstich 2012). Complete rewetting would reduce carbon-dioxide emissions in the same range as a 40% reduction of emissions from passenger car traffic. Besides, even more carbon dioxide will be saved by the replacemt of of fossil sources of energy when using renewable raw materials and through energy savings due to the use of this novel insulating material. It remains to be examined to what extent the saved volume of emissions can be quantified and, possibly, be sold as corresponding Credits on the voluntary carbon market.

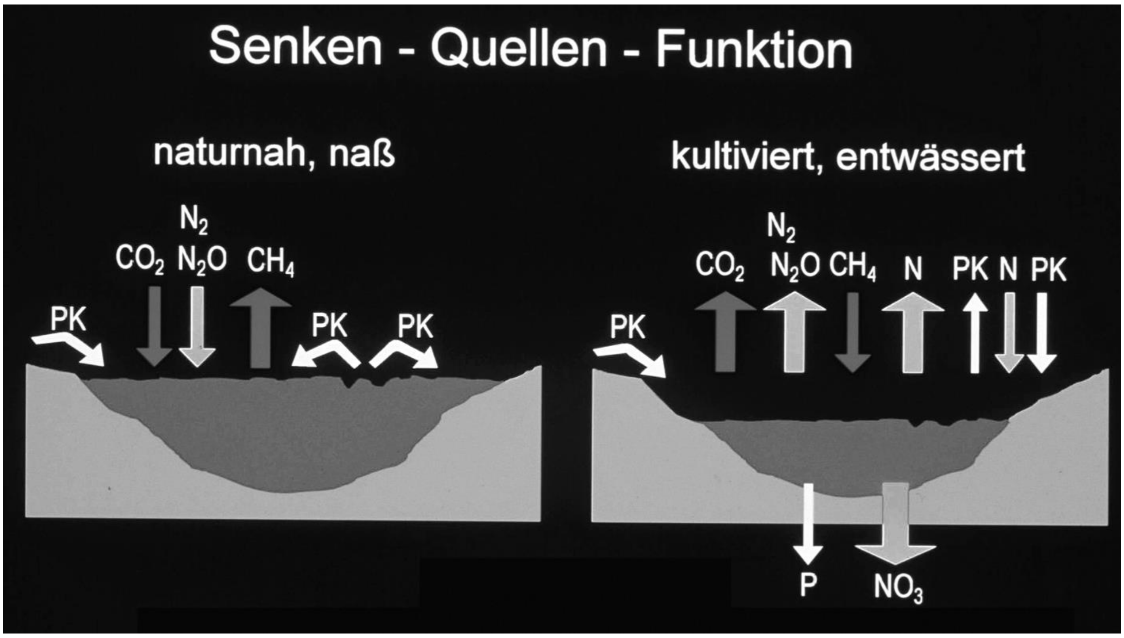

Figure 3. Protection of waters (source: TU Munich)

From the environmental point of view, an additional advantage is given by the fact that cultivated typha crops provide an ecological niche with habitat space for animal species worthy of protection that are characteristic for fenlands (for example, the Common Snipe, declared 'Bird of the Year' in 2013). In this respect, the harvest does not mean a restriction at all, as it occurs in wintertime outside of the laying/ breeding periods when the animals have left and there are no nesting sites. At the same time, typha cultivation contributes to water protection. Thanks to the areas under typha cultivation, large quantities of surface water can be thoroughly cleared of nutrients and pollutants before re-entering the water circulation. Moreover, cultivated typha stands will protect the area from continued soil erosion. Besides, the cultivation of typha plants contributes to the creation of retention areas to prevent floods, without endangering agricultural benefits and crops.

3 SUITABILITY OF THE PLANT FOR THE PRODUCTION OF BUILDING MATERIALS

Due to the specific structure of their leaves, typha plants are particularly suited for the production of building materials and insulating materials to be used in structural applications. The smooth, tough external skin covers an internal system of small chambers. The walls of these chambers, which follow the direction of the leaf axis, form veins that connect the two surfaces of the leaf. The chambers are filled with a fine-threaded sponge tissue. This forms a microporous structure that is comparable to hardly any other industrially usable plant material.

Due to the combination of tensile longitudinal fibres and elastic spongy tissue, the leaves are characterized by a high level of breaking resistance and tensile strength and remain flexible and dimensionally stable also when dry. Even after frequent compressions, they will regain their original shape and do not show any damages, neither at the skin nor at the infrastructure. Regarding compression and tension, the performance of the leaf material is totally different in the direction of the leaf axes and perpendicular to the leaf axes: along the axes, the leaf material resists high pressure loads of approx. 1 N/mm² and even higher tensile loads. The leaf material undergoes elastic deformation even at very low pressures of 0.01 N /mm across the fibre direction. As was found to be particularly true for the isotropic, magnesite-bonded panel version, these two different properties are crucial for the special qualities of the material. Due to the spongy tissue, having a thermal conductivity of approx. 0.032 W/mK, the product additionally features good thermal insulation properties. To be able to resist the aggressive swamp climate, the plant is endowed with tannins (polyphenols). This is an important prerequisite for building applications, as it makes the use of problematic, chemical additives unnecessary, which would inhibit composting.

In the last few years, scientists of the Fraunhofer Institute for Building Physics IBP have carried out a series of laboratory and field tests of various products based on typha in cooperation with the inventor Dipl.-Ing. Werner Theuerkorn. This research work resulted in a series of products, among which mainly the mineral based, isotropic typha panel material is particularly interesting. The fundamental production principle of randomly arranged, magnesite-bonded particles of typha leaves (that nevertheless run parallel to the panel plane) thus provides the basis for a material that can be produced in a relatively uncomplicated manufacturing process. This created a product, which includes no other additives besides plant components and a purely mineral bonding agent, thus ensuring full compostability. Despite its low thermal conductivity of 0.055 W /mK, the recently developed new magnesite-based typha panel is characterized by extremely high strength and dynamic stability, thus making it suitable for further uses with regard to static applications. Besides, this new building material features several additional positive characteristics, including:

- Renewable building material featuring high resistance to mould infestation;
- Enhanced protection against fire, noise, and overheating in summer;
- Convenient and simple workability – using any common tools;
- Relatively diffusion-open and capillary-active;
- Production requires only low energy input;
- Full recyclability.

4 EXEMPLARY APPLICATION: HALF-TIMBERED BUILDING

Construction work at the Nuremberg half-timbered building with its asymmetrical building structure, featuring a half hipped roof and insufficient reinforcement of the load-bearing structure, required several measures: restoring the building's exposed timber framework, ensuring compliance with the German Energy Saving Ordinance (EnEV 2009), and considering aspects of heritage buildings while stabilizing the building. The applied typha board material meets these requirements. The exemplary application of the typha material (Theuerkorn et al. 2013) was funded by the German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt, DBU) and by the Bavarian State Office for the Preservation of Historical Monuments (Bayerisches Landesamt fuer Denkmalpflege). Using the typha boards, an extremely lean external wall construction of 160 mm plus 40 mm of render with panel heating was achieved. The material's easy workability and high inherent stiffness allowed to fit the typha panels to the irregular, sloping walls. The external plaster was directly applied to the typha boards (as a particularly vapour permeable, triple-layer plaster) and armed with parachute seeds of the cattail plant. During an 18-month monitoring period, Fraunhofer IBP measured the functionality of the wall construction and established a mean thermal transmittance (U-value) for the entire construction (infill panel and timber construction) of 0.35 W /m²K. The moisture that was introduced by the swelling mortar and the plaster rapidly dried, resulting in a non-critical value in the timber post of less than 20 m.-%.

Figure 4. Photography documenting the condition of the half-timbered building before refurbishment

Figure 5. Exterior view of the timber-frame construction after renovation
(photos by Alexandra Fritsch)

5 EXEMPLARY APPLICATION: TIMBER FRAME BUILDING

The first new construction in the Radolfzell area to integrate typha boards is a newly raised sauna building, which completes an existing wellness resort. The building site is located close to a landscape conservation area that also hosts typha stands. External and internal walls were filled with typha panels, which are used to provide both thermal insulation and ensure the longitudinal reinforcement of the walls, which allows to use a very large grid of 4.3 m in total. The requirements regarding sound insulation and protection against fire are also met. The external wall construction (with a total thickness of 240 mm) was filled with two directly fastened 90 mm typha boards, joints were covered by overlapping of the panels. In addition, the outside of the wall was covered by 60 mm boards. The external wall was directly covered with lime plaster; on the inside, clay plaster was applied directly to the boards. By this, a relatively diffusion-open wall construction with a U-value of 0.23 W/m²K was achieved. The interior walls are made of two layers of 60 mm typha boards, both surfaces of which are covered with clay plaster. The construction of this sauna building is a unique example of successfully implementing the 'cradle to cradle' requirements. This is the first new construction that uses a material which combines all structurally relevant properties: static reinforcement (bracing), thermal insulation, noise control and fire protection.

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