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Oxygen in wetland plants

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Introduction

Due to the lack of oxygen in wetland soil, it is of special importance for the resident plants to have mechanisms to cope with this anoxia. An example for those mechanisms is an aerenchyma, which allows for easy transport of gases through the plants. An aerenchyma is a porous tissue, made out of gas-filled cells. Those special spaces are created either by schizogenous (dividing) or lysigenous (collapsing) cells. The plant specific morphology is determined by the environmental factors of the area. The question to be answered is how the oxygen level varies during the period of one day. The diurnal changes of oxygen depends on diverse factors like the surrounding temperature, air humidity and the intensity of photosynthesis active radiation. The results of this experiment may allow to have a better understanding of the adaptions in wetland plants exposed to low oxygen contents in their surrounding. For this experiment, the oxygen level in the rhizome of *Typha domingensis* was measured.

A second experiment was conducted, to analyze the oxygen gradient radiating from *Phyllantus grandifolius L.* and *Syzygium jambos L*. This is done by the use of Microx optodes, measuring the concentration in the soil of the plants. A gradient should be observeable in the surroundings, getting lower in concentration the further down the measurements are taken, due to the changes in aeration further down in the soil.

Material and Methods

For the measurement of oxygen in Typha domingensis we used a DL2-Logger to measure the environmental conditions like temperature, humidity and the photone flux density with preinstalled sensors. We used needles to put holes into the rhizomes. Inside those holes we insert fibre-optic microsensors with a capillar for a better access to the rhizomes. The sensors were connected to an Oxy-4-micro logger with four channels: plant 1 to channel 1 with sensor TA35, plant 2 to channel 2 with the sensor TA40, plant 3 to channel 3 with sensor TA37. We started at 4.21 p.m. on monday, 14th of september and logged the data each minute during the night until 11.42 a.m. For the analysis of the data, we saved the files to a computer.

Figure 1 : First experiment

The second task was to find out, if there is a gradience of oxygen in the soil of pots inside the botanical garden. We also used fibre-optic sensors and a febox to save the datas. The microsensor of the first pot with Syzygium jambos had the following numbers: 115, 82, 79, 81, 90, 96, 94, 78, 83. The numbers of the second pot with Phyllanthus grandifolius were 115, 82, 79, 94, 90, 83, 81, 78, 96. We took several microsensors of different length with 1, 2, 5, and 10 cm to get data of several depths in the soil and marked the sensors with Parafilm.

Figure 3 : The Fibox (Fa.PreSens) with it cable

Figure 2 : Insertion of the sensors on the soil

Between each measurement, we did a calibration due to the conditions of the soil. We also measured the shift of the light between the inside and outside and the temperature.

Results

First experiment

Figure 4 shows the results of the measurement of oxygen in the rhizomes of Typha domingensis. The x-axis gives a time scale whereas the y-axis shows the measured percentages of the different lines. The substrate temperature stayed around 14 degrees during most of the time period and increased up to 16 degrees in the morning (10:13). The amount of oxygen in the plants was measured in percentage of air saturation, which means that 60% airsat. are 60% of the 21% of oxygen that is in our air. Plant 2 and 3 revealed an oxygen concentration below 60% in their rhizomes. It stayed around 56% airsat. in plant 2 and 58% airsat. in plant 3. Both curves showed an increase of oxygen in the morning hours at the end of the measurement. The rhizome of plant 4 had an oxygen amount of around 80% airsat. which maintained on this level almost during the entire time period. During the morning, the oxygen level in plant 4 dropped to 75% airsat. The humidity of the air revealed some ups and downs at the beginning of the measurement but always stayed above 80%. During the time of the measurement the humidity is around 90% and decreased in the morning hours to below 80%.

Figure 5 : Oxygen in the rhizomes of Typha domingensis

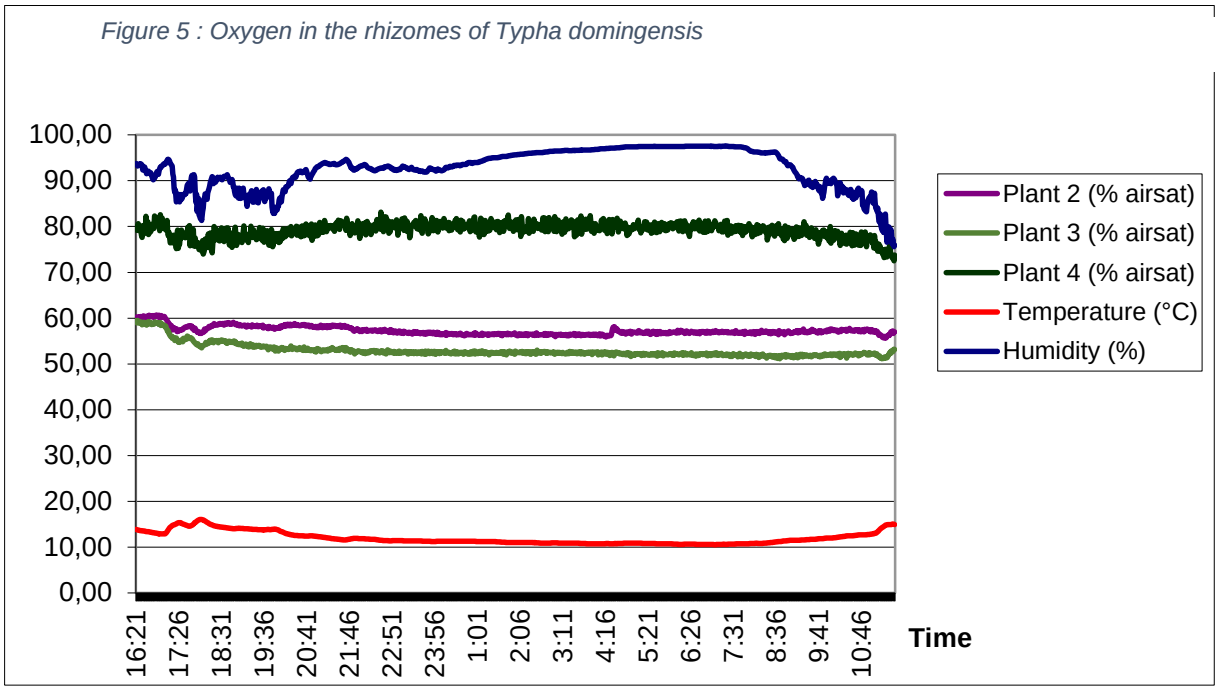


Figure 4 : Oxygen in the rhizomes of Typha domingensis

The dark green line illustrates the oxygen amount in the rhizomes of plant 4. As it is shown plant 4 has an oxygen amount of around 80% airsat. and maintains the amount during the entire time. At the end of the green curve there is a decrease. The oxygen level in plant 4 drops to 75% airsat. The humidity of the air is given in the blue curve. It reveals some ups and downs at the beginning of the measurement but always stays above 80%. During the time of the measurement the humidity is around 90% and increases in the morning hours to under 80%.

Second experiment

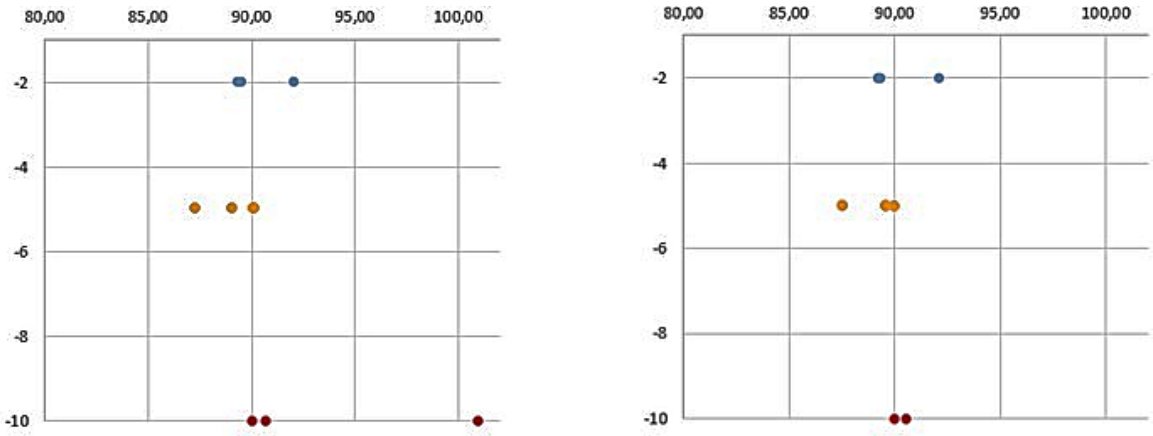
Table 1 gives the name of the plant species, the depth of measurement and the corresponding percentage of oxygen saturation

Table 1: Percentage of air-saturation by depth in 2 pots

Plot	Depth	% air-sat.
Syzygium jambos L.	-2	92,13
	-5	89,99
	-10	90,07
	-2	89,24
	-5	87,57
	-2	89,40
	-5	89,57
	-10	90,56
Phyllanthus grandifolius L.	-2	92,00
	-5	90,11
	-10	90,03
	-2	89,36
	-5	87,30
	-10	90,68
	-2	89,45
	-5	89,05
	-10	100

The data is depicted in table 1

Figure 5: Oxygen (in % of air-saturation) in 2, 5 and 10 cm depth in 2 pots



Discussion

First experiment

The graphs show a more or less stable trend during the time. We expected to see a clear increase and decrease of the amount of oxygen in the rhizomes, depending on the use of oxygen of the plants. There could be many reasons for the results in this case. *T. domingensis* is for example not a common plant in this region so there could be some differences of the species and their usual habitat the reason for these nearly stable data. Also the time, used for the measurement of oxygen and the environmental conditions could have an impact on the results. For this experiment, a range of 19 hours was used for the measurement. In other cases often two to three days were used to gather the data. A bigger time scale like at least two or three days is often better for the measurement because there are more data to gather, respectively there is a bigger range to observe, if there is a gradient or a trend of the amount of oxygen to see or not and if there is a diurnal fluctuation. The diurnal fluctuation depends often on the light intensity why a time scale of several days for the measurement could lead to better results than only a few hours. Also, the quality of the substrate could be important for the data, e.g. its ability for the uptake of the oxygen, released by the roots of the plants. Besides, a possible faulty installation of the microsensors into the rhizomes could lead to wrong data.

The other data, which were gathered during the measurement, show the environmental conditions of the plants like the air temperature and air humidity as well the temperature and humidity in the soil and the photosynthetic active radiation (PAR). The cool temperatures and the fact that the experiment was performed at the end of the growing season are possibly the main reasons why the observed oxygen saturations in the rhizomes showed rather no diurnal

pattern in terms of ventilation. Nevertheless, the results of this experiment show that here is at least a gradient to see.

Second experiment

We expected to find a marked vertical oxygen gradient over the distance up to 10 cm below the soil surface, which could, however, not be observed. That means the soil was well aerated. It could be because the soil was mixed with granules and volcanic ash, which decrease soil compaction.

References

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