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利用大豆光谱特征判定地下封存CO2泄漏

Judgment of CO2 leaking in underground storage using spectral characteristics of soybean

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中文摘要:

碳捕捉与储存（carbon capture and storage，CCS）技术可以减少CO2气体排放，从而减缓全球气候变暖。但把CO2液化后进行地质封存具有泄漏的风险，如何大面积速、高效地监测CO2泄漏点是一个技术难题。该文通过野外模拟试验，以大豆为试验对象，研究了地下储存的CO2轻微泄漏对地表植被及其遥感特征的影响。大豆在20月4日播种，自7月4日开始CO2气体以1 L/min的速度持续注入土壤中，每天测量土壤中CO2体积分数（土壤中CO2气体占土壤中总气体体积含量的百分比）、每周测量1次豆叶片的SPAD值、光谱数据。试验结果表明，当土壤中CO2体积分数小于15%时，对照（CK）与CO2泄漏胁迫大豆SPAD值无显著性差异（P＞0.1），当土壤中CO2体积数大于等于15%时，CK与CO2泄漏胁迫大豆SPAD值具有极显著性差异（P＜0.001），随着胁迫进行大豆会早熟、落叶，甚至枯死。利用连续统去除法对大豆的光谱数据行处理，发现随着土壤中CO2体积分数的增大，在绿光区的光谱反射率逐渐增大，而其他波段则无明显变化规律。根据CO2泄漏胁迫下大豆的光谱变化特征，设计采用植被指数Area(510～590 nm)（510～590 nm光谱曲线所包围的面积）识别遭受CO2泄漏胁迫的大豆。结果表明，当土壤中CO2体积分数大于等于15%时，Area(510～590 nm数可以较好地识别出遭受胁迫的大豆，且具有较高的可区分性及稳定性，但当土壤中CO2体积分数小于15%时，该指数在整个生育期内无法准确识别出遭受胁迫的大豆研究结果对未来地表生态评估、高光谱遥感监测CO2泄漏点具有重要意义与应用价值。

英文摘要:

Abstract: To mitigate the global warming caused by the excessive emission of CO2, Carbon Capture and Storage (CCS) techniques have been proposed to reduce the concentrations of atmospheric CO2 and to slow down the change of climate. However, everything has two sides for there is a risk of the CO2 leakage from the stored sites that ma impact the surrounding environment significantly. Therefore, the monitoring of CO2 leaking spots has become a crucial issue to be solved in applying CCS. It is therefore needed develop a large-scale, quick and highly efficient method for detecting the CO2 leakage on the surface of the sequestrating fields. Considering that the hyperspectral remote sensin technique can monitor the slight changes of surface vegetation by spectral feature analysis, this paper is dedicated to studying the impacts of the slight CO2 leakage stress on th surface vegetation through simulating experiment in the field. The experiment was carried out from May 2008 to August 2008 at the Sutton Bonington Campus（52.8 N, 1.2W）of University of Nottingham. Beans (Vicia faba cv Clipper) were sowed by hand on June 4th, 2008. From July 4th on, the controlled CO2 was injected into the soil at a rate of 1L/min, the concentrations of CO2 in the soil were measured every day in the field. Additionally, the chlorophyll contents and spectral data of beans were measured one time every week i laboratory. The results showed that when the concentrations of soil CO2 was under 15%, there was no significant difference for chlorophyll contents between the control and str beans (P>0.1). However, when the concentrations of soil CO2 was above 15%, there was a great significant difference for chlorophyll contents between control and stressed bean （P<0.001）. As the time passed by, the experimented beans became premature senescent, experienced fallen leaves, and even died. The spectral data were processed by the continuum removal method and the results indicated that in the green bands the spectral reflectance gradually increased as the CO2 concentrated in the soil; nevertheless, in othe bands there were no apparent and stable rules that could be derived from the spectral analysis for the whole growth stage of beans. According to the spectral feature analysis of under the stress of CO2 leakage, a new index (Area(510-590nm)) was designed to identify the beans. The experiment results showed that the Area (510-590nm) index was able to identify the stressed beans when the CO2 concentrations in the soil were above 15%. However, the index was unable to identify the stressed beans when the CO2 concentration i soil was fewer than 15%. It can be concluded that the research is of great importance and has application value for detecting the leakage spots, monitoring and evaluating land-su ecology under CO2 leakage stress.

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