Detection of Spectral Features of Anomalous Vegetation From Reflectance Spectroscopy Related to Pipeline Leakages

M. van der Meijde, H.M.A. van der Werff, and J.F. Kooistra

Underground pipeline leakage inspection is an open problem with large economical and environmental impact. Traditional methods for investigating leakage and pollution, like drilling, are time consuming, destructive and expensive. A non-destructive and more economic exploration method would be a valuable complement to sub-surface investigative methods. Reflectance spectroscopy (or hyperspectral remote sensing) proved to be a tool that offers a non-destructive investigative method to identify anomalous spectral features in vegetation.

One of the major environmental problems related to pipelines is the leakage of hydrocarbons into the environment. Hydrocarbons can establish locally anomalous zones that favor the development of a diverse array of chemical and mineralogical changes. Any vegetation present in these zones is likely to be influenced by the hostile and polluted environment. Geobotanical anomalies occur as a result of the effect of hydrocarbons on the growth of vegetation. The most likely changes in the vegetation are expected to occur in the chlorophyll concentrations which are an indicator of the health state.

This is the main conclusion after an extensive field campaign in May 2004 in Holland investigating a 1 km trajectory of a 21 km long pipeline. The pipeline is ‘sweating’ benzene condensates at approximately 50% of the connection points between the 9 meter segments of the pipeline. Spectral measurements were conducted at four different test locations in the 1 km trajectory. The test locations were covered by long grass, one of the fields was recently mown. Using different survey designs we can confirm the presence of geobotanical anomalies in different locations using various spectral interpretation techniques like linear red edge shifts, Carter stress indices, normalized difference vegetation index en yellowness index.

After the interpretation of the geobotanical anomalies, derived from hyperspectral measurements, we compared the findings with information on pollution levels obtained by drilling at these specific locations. We can confirm a strong coherence between pollution levels derived from the drilling and the geobotanical anomalies interpreted from the spectral measurements. Comparison with aerial photographs in the visible and near-infra red for the same 1 km trajectory shows that our geobotanical anomalies coincide with the anomalous regions in the photographs.

A combination of the three methods; drilling, aerial photography and field spectral reflectance measurements, will give an almost compete signature of the pollution present in a region. Using aerial photography for large scale analysis and field spectral reflectance measurements as a detailed follow-up investigative method we developed a very strong and effective, both in time and costs, method for pollution detection and monitoring. Ground validation in the form of drilling is still required but can be limited to only a few selected locations.