

# **The Added Value of Reflectance Spectroscopy in the Detection of Pipeline Leakages**

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Inspection of underground pipeline leakage 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. 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, and has a significant added value to traditional methods. The use of reflectance spectroscopy relates directly to one of the major environmental problems related to the leakage of hydrocarbons into the environment from pipelines. Hydrocarbons can establish locally anomalous zones that favor the development of a diverse array of chemical and mineralogical changes. Geobotanical anomalies can 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. We investigated a 1 km trajectory of a 21 km long pipeline in May 2004 in Holland. 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 locations in the 1 km trajectory. Using different survey design, we can confirm the presence of geobotanical anomalies in three of the four locations using various spectral interpretation techniques such as linear red edge shifts, Carter stress indices, normalized difference vegetation index en yellowness index. From comparison of our findings with information on pollution levels, obtained by drilling at these specific locations, we can confirm a strong coherence between these elevated pollution levels and the geobotanical anomalies interpreted from the spectral measurements. However, in one of the fields, that actually was declared clean from the drilling analysis, we detected anomalies in a very regular pattern along the pipeline, suggesting leaking connector points. This implies that we can identify pipeline leakage using reflectance spectroscopy before environmental threshold values for this specific pollution problem are exceeded. We conclude that reflectance spectroscopy can be very useful in early detection of pipeline leakage. For future work we will extend our method with air- or spaceborn spectral measurements for large scale analysis whereas field spectral reflectance measurements will be used as a detailed follow-up investigation method. We aim to develop a robust and effective method, both in time and costs, for pollution detection and monitoring in which ground validation in the form of drilling is still required but can be limited to only a few selected locations.