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Using Satellite Images To Identify Salinity Intrusion For Four Provinces Near Northern Delta's Coastline In Vietnam

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Abstract: Using satellite data from the MODIS image to develop the salinity map of four coastal provinces in the Red River delta in Vietnam with the advantage of high resolution and large research area (2,330 km). However, the disadvantage of MODIS is less accuracy, especially for mild and moderate degraded lands. Using the method of measured directly by pH meter and experimented by ultrasonic spectrometer at Giao Thuy district, Nam Dinh province to compare with the interpretation results of the MODIS image. The results obtained (non-saline soil) is a similarity. However, when combined with remote sensing data only shown compatibility in qualitative terms (the closer of the sea the higher salinity level, the Southwest's salinity tends to be higher than the Northeast) but there is no compatibility in quantitative terms. To determine this correlation, need more field data and other in-depth studies of both space and time.

Keywords: MODIS image, salinity map, remote sensing, Namdinh province, GIS.

1. INTRODUCTION

Using data collected from MODIS of the Institute of Physics in Vietnam created to detail salinity map of four provinces at near Red river Northern delta's coastline. High resolution of MODIS is suitable for a large area researching (2,330 km) however its accuracy is not high, especially for areas where slightly or moderately the land degraded. By using direct pH measuring method and ultra high frequency spectrometer at Giao Thuy district in Nam Dinh province to compare with results from MODIS imagine interpretation we have some opinions such as: When we compare between 2 measuring methods the result showed that there isn't difference between them (the soil is not salinized). However when we combine with data from satellite images similarities the result showed that there is difference between them. They can be found only a part compatibility (the salinity of sea water nearer of the land is higher than farer areas; the salinity level in the South West is higher than in North East) but there's no quantify compatibility. In order to confirm this relation there's a need for more field data and substantial researches in both space and time. Vietnam is a country with a long coastline, large coastal plain but always faces with the possibility of salinity. Nowadays, under the influence of climate change, such as the rising of the sea level, the salinization is getting more and more severe, especially for some seaside provinces belong to Red river delta like Nam Dinh, Thai Binh... In the 21st century, creating maps to observe the current of salinization by using long range surveillance and GIS is a popular trend because of its time-multibility. In previous times, almost countries in the world used data's satellites (Landsat, IRS, SPOT...) to assess the salinization process and soil degradation. But they are limited in range (less than 50 km^2) and accuracy. To overcome these shortcomings, recent studies have used MODIS satellite data. However MODIS prescision is not still up to par, especially to medium or lightly degraded soil. Using ultra high frequency spectrometer and handheld pH measuring device is needed to analyze and review the current salinization level of 4 provinces near Northern delta coastline and this is purpose of this study.

2. Data and methods

Using indirect measure method with ultra high frequency spectrometer with 3 channels L,C,X combine to GPS. Testing 3 times (at 6/2018, 10/2018, 6/2019), collecting 65 soil and water samples. The controlling position is on a rice field at Giaochau village, Minhchau commune, Giaothuy district, Namdinh province. The measuring process is divided to: Equipment correction; collecting samples; measuring EC by handheld equipments; measuring radiation by ultra-high frequency spectrometer. *MODIS data*: Using MODIS data sources from satellite picture receiving station of Institute of Physics Vietnam with a large area (2,330 km^2). Combining two different data of MOD 09 (MYD 09). *Combine data*: Ground data collected in June and October in 2018 and 2019. That time rice was reaping so the vegetation was the thickest. Salinization map is created by some statistical methods (Kriging, Co-Kringing, Inverse Distance Weighting) and using results about pH and EC. Using 18 indicators from MODIS data applied to ground measurements. Then, we will establish Pearson correlation between remote sensing indicators and field conductivity measurement results. The purpose is to evaluate the effectiveness of applying each of these indicators in the classification of saline soils. The LSU method used to compact the data is derived from the multi-spectral MODIS image. Based on the three maps (plants, soil and clouds), each pixel of the image will be considered a linear combination of the reflectivity of the three components. *Salinity map*: Salinity map is built based on the use of salinity index (SI), standardized salinity difference index (NDSI), and brightness index (BI) (Khan et al. 2001) and the results of the research on the salinity indicators of the India-Netherlands Network Project (IDNP 2002)... These indicators are combined with the images MOD09 and MYD09 to detect the zones where low and medium saline areas in Giao Thuy. 18 combinations of universal channels MOD09 and MYD09 are used in the implementation process. These indicators are divided to four groups: salinity index; plant index; channels MOD09 and MYD09 and *How to extract the endmember*: using a number of different techniques to automatically extract the spectrum of endmember from remote sensing data such as Pixel Purity

Index -PPI, Iterative Error Analysis - IEA, Automated Morphological Endmember Extraction - AMEE. In this study, PPI was used to find the most pure spectral pixels in the MODIS spectrum using the environmental image display software (Environment Visualizing Images - ENVI).Results and discussions

3. Results and discussions

3.1. Results of measuring soil salinity by super high frequency spectrometer

Super high frequency spectrometer does not measure soil salinity directly; it only measures the natural emission of soil. Then the natural emission data of the soil is treated by Excel software to be compatible with the output data of the Radio Meter 5.0 software which can determine soil salinity. Although indirectly measured, it has the advantage of being able to execute on a large area in a short time, overcoming the fast changing characteristics of space and time. The model of salinity calculation is run in the range of from 0 to 40 ppm corresponding to each measuring angle of the emission change from 0 to 60˚. The results of measurement on the ultra-high frequency spectrometer have not detected salinity in accordance with the emission measurement value. The results of measuring the salinity of soil samples taken from the field are very low from 0.7 to 0.9 mg/kg; this result shows that the surface soil layer is not saline. Based on this result, we can give some comments:

- The model used for calculation is affected by many other factors such as soil moisture, soil properties.
- The calculation model is only suitable in laboratory conditions when conditions are well controlled;
- The soil sampling area is rice growing area so salinity level is not high;
- The time of measurement coincides with people make soil time so the salinity of the soil be washed away;
- Super high frequency spectrometer using L = 1.4 GHz band is only good for measuring the emission of surface soil but detecting soil salinity in deeper soil is not suitable.

3.2. Results of measuring soil salinity by a handheld meter

Results of measuring salt content (by EC) in soil and groundwater in shallow layer are shown that at the measurement points located relatively far from the coast (points: from 2 to 7 and from 10 to 12) salinity level is not high. Except points 2 and 11, the salinity level in the dry season is higher than the rainy season. However, in the dry season of 2018, salinity level at some points (4, 6, 7, and 10) is increased but at point 2 and 3 is decreased. For coastal measurements (points: 9, 13-15) salinity level is higher at the beginning of the rainy season but reducing at the beginning of the dry season. Particularly, at point 8 is quite strange: salinity level is increased significantly in the dry season of 2018 but almost negligible in the rainy season of 2019. In the dry season, the trend of salt content in the soil and groundwater (low layer) is increased at the two sides of the Red River. They created a strip with high salt content. Their concentration varies from 0.5 to 6 mg/liter. The content of salt of Giaothuy province is high they varies from 4 to 6 mg/liter, at Trucninh province from 3 to 5 mg/liter, Namdinh City from 2 to 3 mg/liter and Haihau province is less salinity, their concentration varies from 1 to 2 mg/liter. Along two sides of the river, the salt content is decreases gradually from 6 to 1 mg/liter at a distance from 0 to 32 km (Fig. 1 and Fig.2).

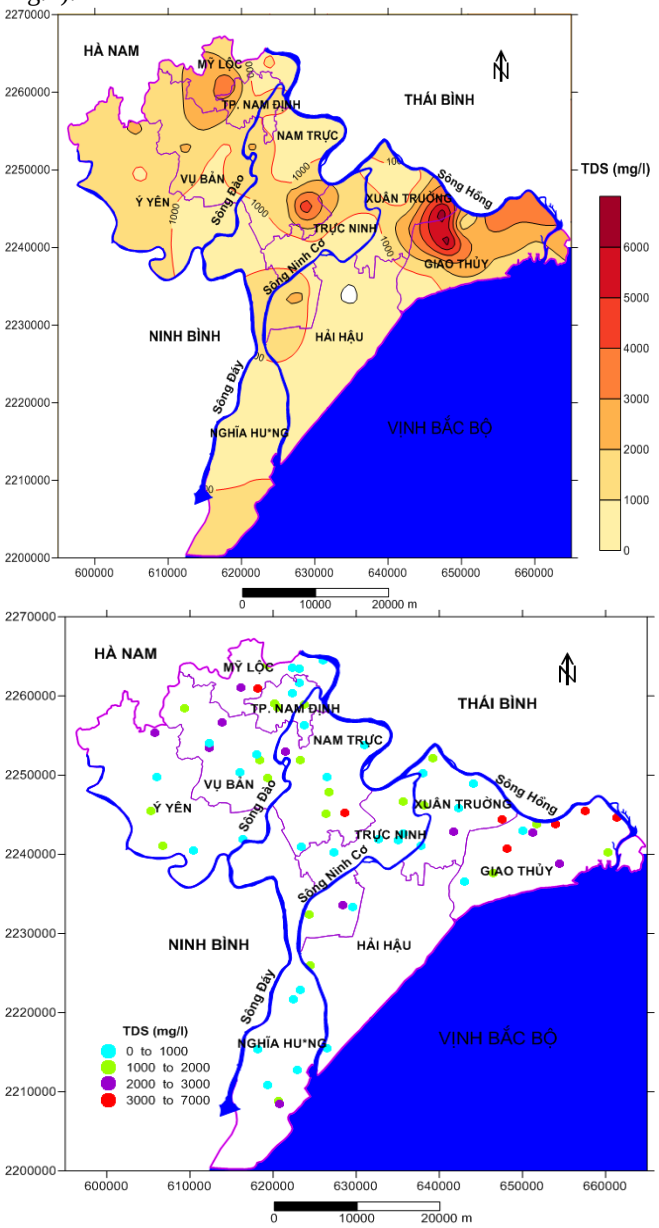

Figure 1, 2: *Mapping of TDS in soil in Giaothuy district, Namdinh province*

Figures 1 and 2 show that the measuring of TDS at points is relatively far from the coast, so salinity level is not high. Salinity level in the dry season is often higher than the rainy season. However, in the dry season in 2018, salinity level of some points was increased suddenly. Because the impact of storms at the end of October 2018.

3.3. Results of monitoring soil salinity by remote sensing images

Creating images by SI2 index of MODIS TERRA and AQUA at the beginning of the rainy season in 2018 and 2019. In black and white images with SI2 index, the more gray areas the more salinity level (or the darker green). Theoretically, the SI2 index will be proportional to the EC index, but the results obtained with the SI2 index are the opposite of those measured by handheld meters. The images with SI2 index show that the closer to the sea the higher salinity level also. Moving toward the Southwest, trend of the salinity level is higher than the Northeast. The more

towards the Middle of Vietnam, the more salinity appears. Because the prevailing wind direction has brought sea water into the mainland area. The trend of salinity level of the sea water is higher towards to Middle of Vietnam. It affects to salinity of the soil. Thus, when combining the traditional measurement methods with with super high frequency spectrometry method, there is a similarity in the results obtained with non-saline soil. However, the combination with remote sensing data only shows qualitative compatibility (the closer of the sea the higher salinity content) but there is no quantitative compatibility. To determine this correlation requires more data in both space and time and other in-depth studies.

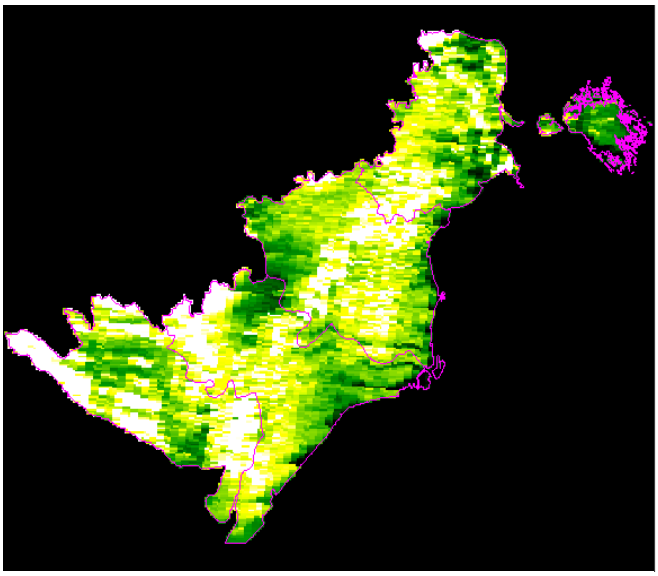

Figure 3. *SI2 index image of MODIS-AQUA probe (June 8, 2018) for 4 coastal provinces in the Northern Delta in Vietnam*

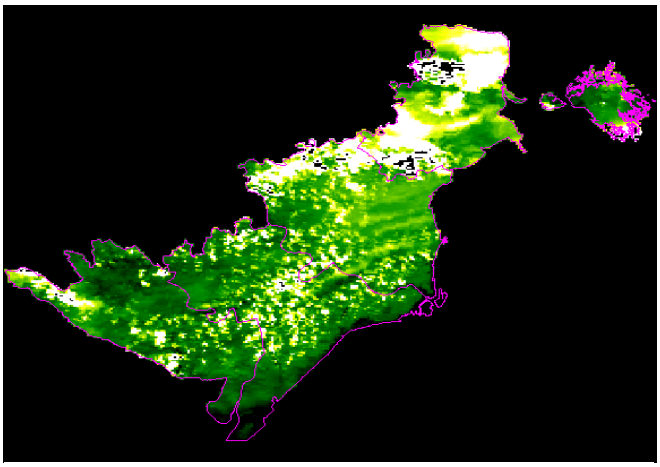

Figure 4. *SI2 index image of MODIS-TERRA transducer (May 31, 2019) for 4 coastal provinces in the Northern Delta in Vietnam*

4. CONCLUSION

To surveillance soil salinity we need to Identify salinize possibility areas and to use proper equipment and method to record the change in the salinity level. The traditional methods are too costly, time consuming and it can't cover a large area. Satellite images and GIS are useful tools to create a map that shown the area be salinity and the salinity level of soil and sea water in order to support land use of local. Using data of MODIS station at Institute of Physics Vietnam with a cover range of 2.330 km^2 to build a map of salinity soil for 4 districts at Namdinh. The results show that the closer sea, the higher salinity level and the South West is saltier than the North East. When we compare the result of two methods, there are some similarities at the points are low salinity level and mild salinity level soil. However when we combine with data from satellites, MODIS images. The results show similarities in essence (salinity level rise when closer the sea) but there's no similarity in quantitative. We need to more indepth researches to improve the accuracy of the salinization map to improve local land planning.

5. ACKNOWLEDGEMENTS

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