INT. J. BIOL. BIOTECH., 15 (2): 263-267, 2018.

MONITORING THE IMPACT OF SOIL SALINITY ON VEGATATION HEALTH USING GEOSPATIAL TECHNIQUES IN THATTA AND SUJAWAL DISTRICTS, SINDH

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ABSTRACT

Soil salinity is one of the extensive environmental threats all around the world, especially in arid and semi-arid areas. Crop productivity and production losses caused by salinization have considerable impact on farm and irrigation project economics.The typical soil survey methods of field sampling, analysis and interpolation of these field data for salinity mapping, over extensive areas are comparatively costly and time consuming(Subramoniam, Bera and Sharma 2011). On the other hand, Satellite Remote Sensing (SRS) data provides pronounced prospective for monitoring dynamic processes, such as salinity.

The present study shows that there is a negative correlation found between the Normalized Difference Vegetation Index NDVI and Electrical Conductivity EC of the soil which supports the fact that the areas having sparse or unhealty vegetation are mainly attributed to increase in saline conditions within the area.

Key-words: Soil salinity, NDVI, Electrical Conductivity, Vegetation, Irrigation, Regression analysis

INTRODUCTION

Soil salinity is one of the widespread environmental threat all around the world, especially in arid and semi-arid areas. Saline soils mainly occur due to irrigation and other extensive agricultural activities which account for a number of soil degradation processes (Akramkhanov *et al.*, 2011)

Mainly two types of salinization are known to occur, namely primary and secondary salinization. Primary salinization is a natural process whereas secondary salinization is caused by human activity (Szabolcs, 1998; Peck and Hatton, 2003; Barrow, 1991; Metternicht, 2001).

The use of primitive irrigation techniques, irrigation using water rich in salt, land clearing and excessive use of fertilizers are among the human induced activities that cause soil salinity together with some natural factors such as parent material in soil structure, closeness of salty ground table to the surface, weathering of the parent rock and sea water lead to soil salinity (Akramkhanov *et al*., 2011).

The global extent of high soil salinity as reported by various authors varies in extent, however about one billion ha of soil is affected by primary salinization and 77 million ha by secondary salinization of which 58% are situated in irrigated areas. In terms of percentages about 20% of irrigated lands are globally affected by salinity (Metternicht and Zinck. 2003; Ghassemi *et al.*, 1995; Stals, 2007).Large areas of formerly productive land are suffering through water logging and salinity in countries like Afghanistan, Pakistan, Syria, and China due to extensive irrigation in arid regions. The process of irrigation is not itself the reason for degradation of land rather its inappropriate may be attributed to the reason behind. The reclamation measures now being successfully applied for some areas in Pakistan and China (Stals, 2007; Al-Khaier, 2003).

The typical soil survey methods of field sampling, analysis and interpolation of these field data for mapping, over extensive areas are comparatively costly and time consuming (Subramoniam *et al.*, 2011). On the other hand, Satellite Remote Sensing (SRS) data provides pronounced prospective for monitoring dynamic processes, such as salinity. Multispectral data acquired from platforms such as Landsat, SPOT, and the Indian Remote Sensing (IRS) series of satellites have been found to be useful in detecting, mapping and monitoring salt-affected soils (Dwivedi and Rao, 1992; Garcia *et al.*, 2005).

Soil salinity is determined by laboratory analysis (electrical conductivity of the saturated soil paste extract ECe) (Darwish *et al*., 2007; Subramoniam *et al.,* 2011). The soils having electrical conductivity of less than 4 dSm^{-1} are considered non-saline. As the conductivity increases, beyond this value the salt content increases and only salt tolerant plants such as halophytes can grow. Crop productivity and production losses caused by salinization have considerable impact on farm and irrigation project economics. For instance, the economic damage caused by secondary salinization was estimated at US $750 million per year for the Colorado River Basin in the United States, US $300 million per year for the Punjab and Northwest Frontier Provinces in Pakistan, and US $208 million per year for the Murray–Darling Basin in Australia (Ghassemi *et al*., 1995).

This paper aims to demonstrate the impact of soil salinity on the plant health and growth in the central region of Thatta district, in Sindh Province. The soil salinity map of the area is also developed using integrated soil sampling as well as Satellite Remote sensing and Geographic Information System (GIS) techniques.

MATERIAL AND METHODS

The Study Area

The study area is located in the lower Indus plain and southeast of Sindh province (Fig. **1**). It comprises Thatta and Sujawal districts, situated at 98 Km east of Karachi. The area is located at 23º 43' to 25º 26' north latitudes and 67º 05' to 68º 45' east longitudes (Nergis *et al.,* 2015).The total area of the two districts is 17,355 square km. In the year 2013, the Thatta district was subdivided so that the right side of River Indus comprises old Thatta district and the left side came under the jurisdiction of newly created Sujawal district. The district is bounded in the north by Jamshoro district and northwest by city district Karachi, in the northeast by Hyderabad while Badin districts in the east, in the southeast by Runn of Kutch area and by the Arabian Sea in the south. The area of Thatta after 2013 is 10,020 sq km.

Data Used

Satellite Remote Sensing data pertaining to Land sat 8 Optical Land Imager OLI image 152-43 of Mar., 2015 have been used. The image is geometrically corrected level 1A being cloud free and of good quality. In addition, soil sample data was collected through field survey to carry out analysis for determining Electrical Conductivity using saturated paste extract method (EC_e) of the selected samples. The survey was carried out in March 2015 to coincide with the date of acquisition of satellite data. The samples were chosen randomly to cover the entire area.

Methodology

The selected data set was radio metrically corrected using ENVI software version 5.3 to obtain radiances. Secondly, the atmospheric correction was applied using ENVI Flash settings. The clipping of Area of Interest (AOI) was applied to select desired study area for further processing.

Normalized Difference Vegetation Index NDVI is a standardized way to measure healthy vegetation. Higher NDVI values, show healthier vegetation while low NDVI shows less or no vegetation. The maximum and minimum range of values is +1 to -1 (Fig. **2**). Negative values, show that it is a water body. On the other hand, NDVI value close to +1, demonstrates dense green vegetation and as the value decreases it shows the health or density of vegetation is declining while NDVI close to zero, shows that there are no green leaves (could be due to heavy grazing) or more likely it could be an urbanized area.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Equation……… [1]

The fieldwork of the current study was undertaken in Mar 2015. The time of survey was appropriate as the satellite data and field survey needed to be on the same date. Further, the concentration of salt in the top soil is highest in this season. The sampling points were chosen randomly to cover the entire study area. All accessible areas were sampled and the distance between sampling points was approximately 4-5 km (Fig.**3**).The samples were analyzed to assess the values of $EC_{e.}$. The extracted salinity classification provides values of surface salinity outcrops. To assess the impact of saline soil, it is important to convert or interpolate these values with the sub-surface salinity conductivity values. In order to extract the sub-surface salinity, the overall surface salinity was interpolated regardless of the land cover features. The interpolation technique used is known as Kriging method. The EC_e values were categorized to develop salinity classification comprising five classes of salinity ranging from non saline to very strongly salinity (Fig.**4**) (Dahnke and Whitney, 1988).

The Hot spot Analysis was performed on each of the NDVI data and Salinity map to determine the statistically significant hot and cold spot. The same were further processed to determine a correlation between the NDVI and EC_e using regression analysis within the study area

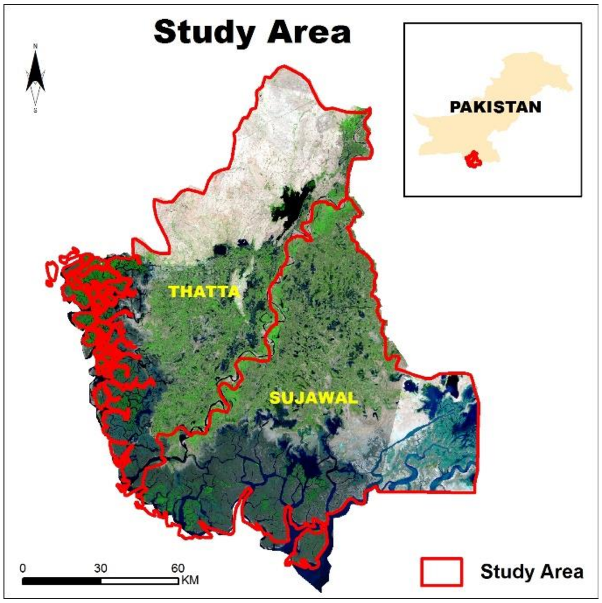

Fig. 1. Location of the Study Area.

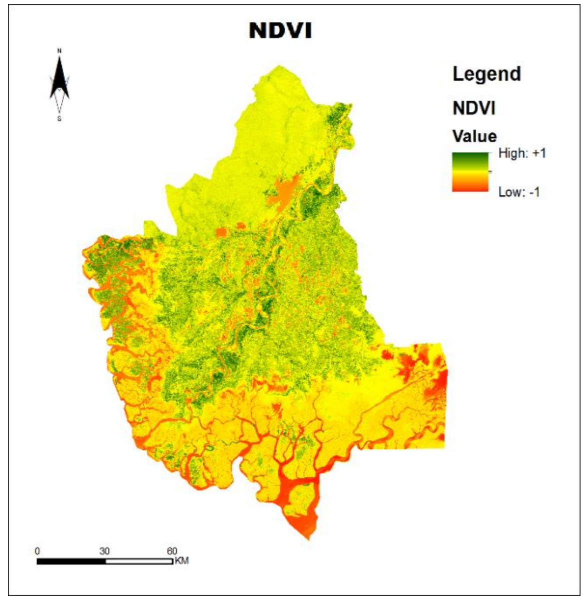

Fig. 2. Normalized Difference Vegetation Index NDVI of Thatta, Sujawal Districts March 2015.

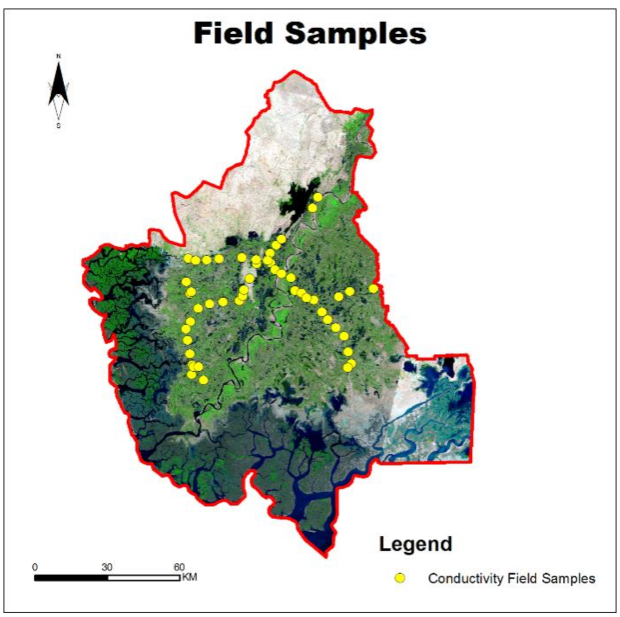

Fig. 3. Location of Field Survey Points.

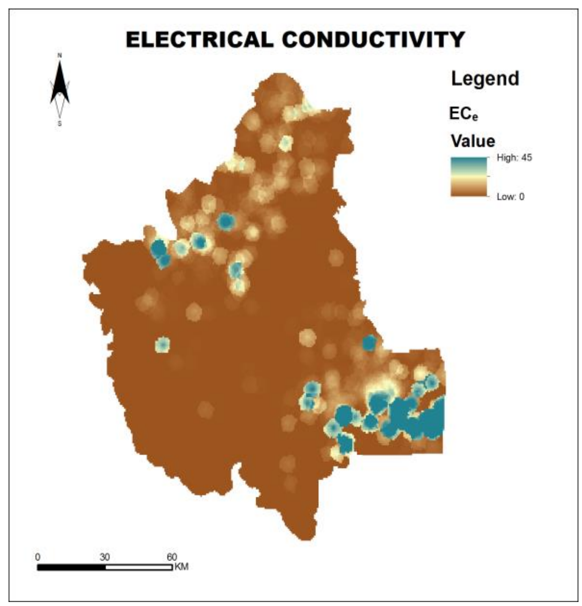

Fig. 4. Regression Map of Electrical Conductivity, Thatta Sujawal Districts, March 2015.

RESULTS AND DISCUSSION

The regressions analysis shows a negative correlation between the two parameters i.e NDVI and EC_e which is found to be – 0.2 (Table 1**)**. This negative correlation is in good agreement with the fact that the area with high values of NDVI i.e. dense or healthy vegetation shows have lower values of EC_e salinity while as salinity increase the vegetation becomes less dense or unhealthy.

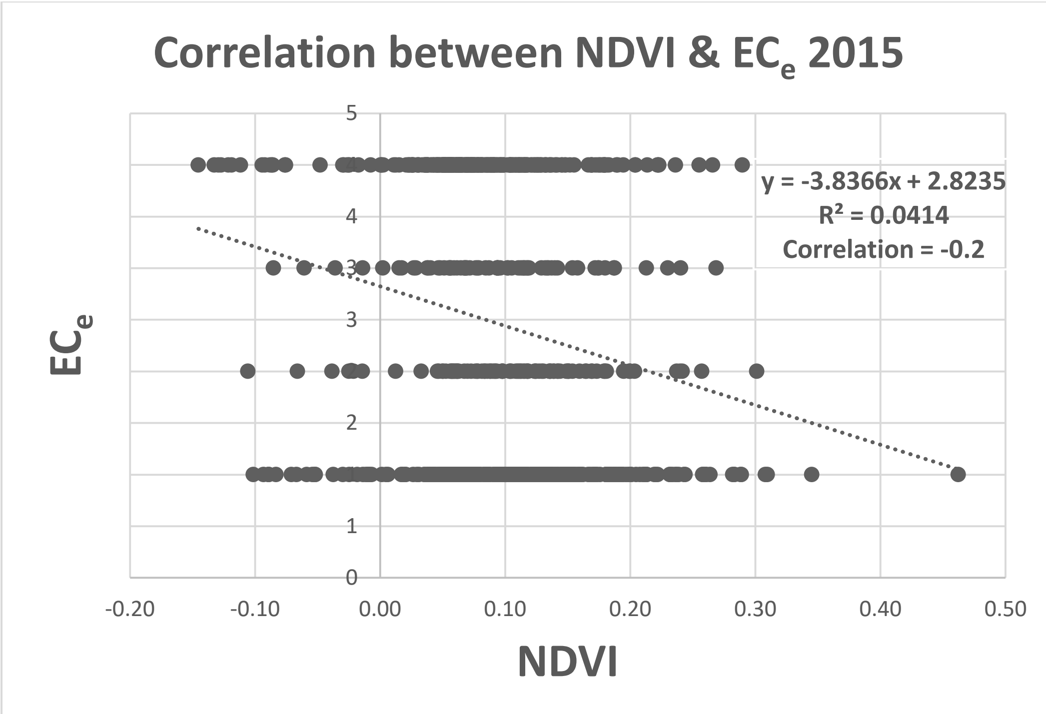

Fig. 6. Correlation between EC and NDVI of Thatta Sujawal Districts, 2015.

The regression equation is shown in equation 2. The value of $R^2$is found to be 0.0414.
y= -3.8366 x + 2.8235 Equation …………[2]

The results of the study are in good agreement with the fact that crop production suffers losses due to increasing salinity in irrigated areas. The results may further be applied to carry out regional level studies in order to combat the severe issue of salinity in vegetated areas. Greater productivity can be achieved if crop calendar of specific crops within an area is also taken into consideration

Conclusion and Recommendations

Ghassemi *et al.* (1995) and Metternicht and Zinck (2003) stated that almost 20%of the world's irrigated land is salt affected and this proportion displays an increasing trend even though considerable efforts are paid to land rehabilitation and reclamation practices. Such saline affected areas cover huge land that makes it quite impossible to examine soil quality with field and laboratory data. With the today's advanced technology, the ground truth measurements must be coupled with especially remote sensing data to achieve best monitoring results. With the use of remote sensing data, one can be able to predict and foresee the sensitive areas and even can improve the number of sampling locations.

Digital soil mapping not only offers a means of predicting and monitoring of saline affected land in a cost and time-effective manner but it also enables to develop digitized maps which is even equally important for the farmers and local authorities.

Crop health and growth is a significantly affected due to the changes in salinity conditions in an area. The same has been demonstrated in the current study by developing a correlation between vegetation stressed areas to that of the extent of salinity. Accordingly, early warning systems against soil salinity may be achievable, which is highly important for increasing crop productivity and even for selecting the appropriate crop pattern. Furthermore, salinity mapping should be preferred to alert people that if no protective measures are taken immediately, the area will become even more saline which in turn be more difficult to cope with (Gorji *et al.*, 2015)

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(*Accepted for publication March 2018*)