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Assessment of Soil Salinity in Southern Shirol Tahsil of Maharashtra (India) Using IDW Geospatial Techniques

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***Abstract* – Soil salinity is a serious problem for agriculture especially in irrigated areas. It occurs in irrigated soil because of the accumulation of soluble salts due to the continuous use of irrigation waters containing high or medium quantity of dissolved salts. The region selected for the present study is southern Shirol tahsil of Kolhapur district. It is located between 16° 33′ 17″ to 16° 43′ 32″ N latitude and 74° 29′ 56″ to 74° 41′ 30″ E longitude occupying an area about 22,840 hectares. The exact position of sampling point in latitude and longitude was identified by GPS. pH value and Ec value are measured by using pH meter and Ec meter respectively. In this study, an attempt has been made to measure the levels of soil salinity by assessing Ec and pH value through IDW GIS techniques. The analysis reveals that deterministic interpolation method like IDW can be successfully used to generate exact continuous surface for saline soil assessment. In denudation slope area, the problem of saline soil is much prominent than surrounding area. Particularly sugarcane has virtually mined nutrients from the soil and the problem of saline and alkaline soil has emerged. Unscientific agricultural practices and irrigation methods, overuse of agro-input, frequent flooding of plain areas have caused degradation in the southern Shirol tahsil.**

***Keywords* – Salinity, IDW, Interpolation, Ec, pH, GIS.**

I. Introduction

Agriculture is an important economic activity, two third of world population is engaged in this occupation. 70% of Indian population is depending on agriculture. It is a major source of food, livestock and agro based industry. Agriculture development has taken place in those areas where it is having fertile soil and availability of water. Soil is one of the most significant gifts of nature to mankind which should be utilized cautiously. But due to the man’s ecological misbehaviors present environment difficulties originate like soil salinity. Agricultural productivity and availability of food is directly related with soil conditions (Pawar C.T. et al., 2009).Irrigated agriculture presently accounts for about one-third of the world’s production of food and fibre; it is anticipated that it will need to produce nearly 50 percent by the year 2040 (FAO, 1990). Hence, it is likely to be difficult, because extensive areas of irrigated land have been and is increasingly becoming degraded by salinization and waterlogging resulting from over-irrigation and other forms of poor agricultural management (Ghassemi, et al., 1995).

In the world, arid and semi arid region is facing the severe problem of soil salinity due mismanagement of irrigation. Soil salinity is a severe environmental hazard (Hillel 2000). Salinization problems continue to spread around the world at a rate of up to 2 million hectares a year, offsetting a good portion of the increased productivity achieved by expanding irrigation (Postel 1999).It adversely affects natural growth of crops and results in less agricultural production. For populous country like India, it is not affordable and permissible to have soil losses in the form of saline and alkaline soil with respect to increasing food demand. Soil salinity occurs in irrigated soil because of the accumulation of soluble salts due to the continuous use of irrigation waters containing high or medium quantity of dissolved salts. Human-induced salinization is the result of salt stored in the soil profile being mobilized by extra water provided by human activities such as irrigation (Szabolcs 1989). Salt – affected soils could be a result of use of salt containing irrigation water, presence of high amount of salt in the soil and high level of ground water table (Horney, et al., 2005). Saline soils lose their productivity and possibility of turning them into unproductive once (Verma, K.S., et al., 1993).Remedial actions require reliable information to help set priorities and to choose the type of action that is most appropriate in each situation (Metternicht and Zinck, 2003).

Available data suggest that the present rate of such degradation has surpassed the present rate of expansion in irrigation (Seckler, 1996). In some places, sustainability of irrigated agriculture is threatened by this degradation (Rhoades, 1997a; Rhoades, 1998).

Knowing when, where and how salinity and sodicity may occur is very important to the sustainable development of any irrigated production system (Al-Khaier, 2003). Therefore, in the present study, an attempt has been made to study the soil salinity analysis of southern Shirol tahsil through IDW techniques. Such studies would be helpful in planning the land resources. For the present study following objectives have been constructed,

1. To assess the geographical characteristics of the study region.
2. To measure the levels of soil salinity by assessing EC and pH conditions and IDW interpolation techniques.
3. To suggest some measures to reclaim the saline and alkaline soil.

Wiegand et al. (1994) have carried out a procedure to assess the extent and severity of soil salinity in fields in terms of economic impact on crop production and effectiveness of reclamation efforts. Their results illustrate the severity of soil salinity and its effects on crops. Ghabour and Daels (1993) concluded that detection of soil degradation by conventional means of soil surveying requires a great deal of time, but remote sensing data and

GIS techniques offer the possibility for mapping and monitoring these processes more efficiently and economically.

II. Study Area

The region selected for the present study is southern Shirol tahsil of Kolhapur district. It is located between 16° 33′ 17″ to 16° 43′ 32″ N latitude and 74° 29′ 56″ to 74° 41′ 30″ E longitude (Figure 1) occupying an area about 22,840 hectares. The study region basically comprises 25 villages of southern Shirol tahsil. This is the flood prone plain region of lower Panchganga basin. This region receives rainfall mainly from south-west monsoon.

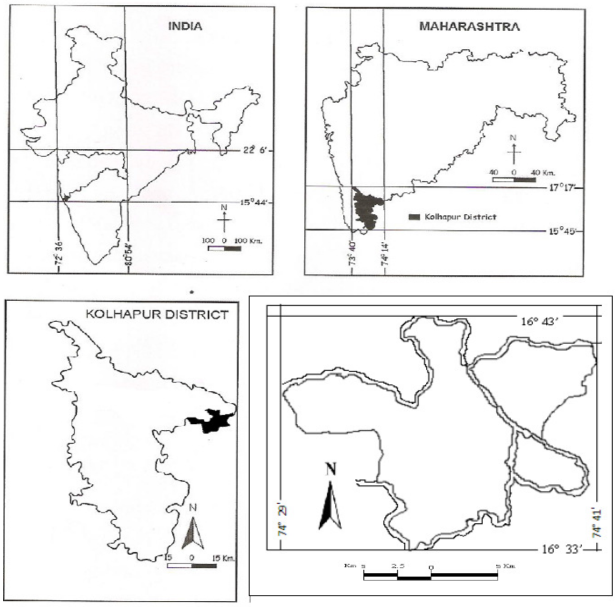

Fig.1. Location Map

III. Methodology

To assess the salinity conditions of the study region, soil samples (Figure 2) have been collected from the study region by applying systematic unaligned sampling technique. Systematic unaligned sampling is commonly used to assure complete coverage of an area. The collected soil samples are further tested in the laboratory for pH and EC analysis. Topographical sheet of Survey of India index no. 47 L/10 with scale of 1:50000 have been used to analyze relief, slope and drainage pattern of the study area. Socio-Economic abstract, District Census Handbooks and District Statistical Abstract are used to assess demographic, irrigation and Land use conditions.

By applying systematic unaligned sampling, 40 samples have been considered for soil salinity analysis. The exact position of sampling points in latitude and longitude was identified by GPS. To measure pH value of selected samples following procedure has been adopted.

3.1 Procedure for measuring pH and EC:

First of all, we have adjusted the pH meter by using pH electrode at standard value of pH 4.0 & pH 9.2 by using standard solutions. Then, we have taken 10 gm of oven dried soil sample in 50 ml distilled water and Stir for about hour at regular intervals to allow the solids to settle down. At last pH reading is calculated for each sample.

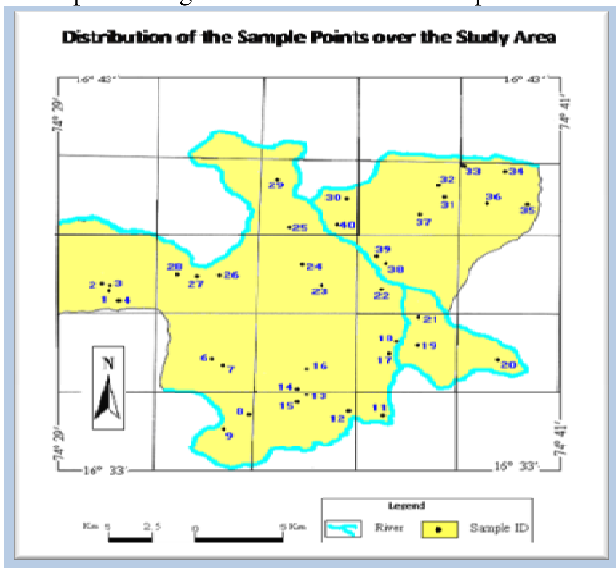

Fig.2. Sample Points in study Area

Ground-based electromagnetic measurements of soil EC are generally accepted as the most effective method for quantification of soil salinity (Norman *et al.,* 1989 and Taylor, 2002). EC is the most common measure of soil salinity and is indicative of the salinity and ability of an aqueous solution to carry an electric current. To calculate EC value following procedure has been adopted.

First of all, we have prepared soil suspension (1:5) by using 10 g of soil and 50 ml of d/w and shaked it mechanically for 1 hour to measure the conductivity of soil suspension by directly dipping the conductivity cell. Then, measured the extracted water for EC by standard conductance meter reported as Mili Siemens per cm (ms / cm) at 25 °C.

To carry out the spatial analysis of EC and pH measurement through selected samples, GPS techniques has been used to plot the sample points on the map. Further, IDW Interpolation technique has been adopted to assess the trend of EC and pH distribution.

The IDW is simple and intuitive deterministic interpolation method based on principle that sample values closer to the prediction location have more influence on prediction value than sample values farther apart (ESRI, 2009). This method is applied to generate a continuous surface by using the sample points to assess EC and pH conditions. The inverse-distance weighted procedure is versatile, easy to program and understand, and is fairly accurate under a wide range of conditions (Lam, 1983).

$$P_i = \frac{\sum_{j=1}^{G} P_j / D_{ij}^{n}}{\sum_{j=1}^{G} 1 / D_{ij}^{n}}$$

Where,
Pi is the property at location i;
Pj is the property at sampled location j;
Dij is the distance from i to j;
G is the number of sampled locations;
n is the inverse-distance weighting power.

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ArcGIS software is used for IDW interpolation. Sample points are marked with GPS locations and attribute data with respect to EC and pH is joined with spatial information. By using spatial analyst tool continuous surface has been generated.

IV. Result & Discussion

The approach presented in this paper involves integration of GPS data for spatial analysis to predict soil salinity through IDW techniques. At first, soil salinity data has been collected from field. The locations of the field sample were recorded on a GPS unit. pH and EC analysis of soil samples have been carried out in the laboratory and statistical surface for EC and pH have been generated through IDW technique.

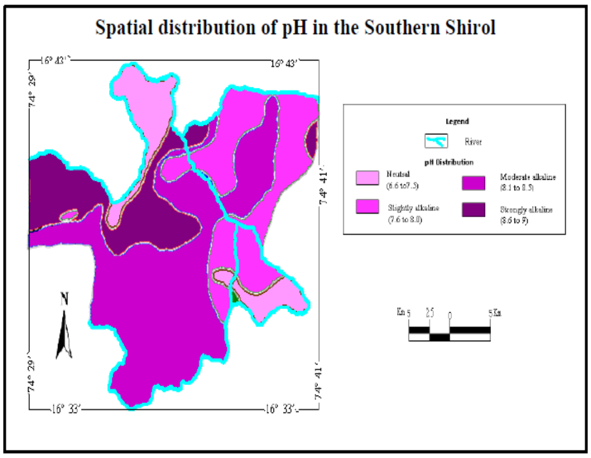

Fig.3. Soil pH Distribution using IDW Interpolation

Table No 1: Sample wise Result of pH and EC analysis

Sample ID	Village	pH	EC	Sample ID	Village	pH	EC
1	Shiradawad	8.39	0.12	21	Rajapur	8.03	0.75
2	Abdullat 1	8.67	0.08	22	Akiwat	7.96	1.01
3	Abdullat 2	7.64	0.02	23	Bastwad	8.98	9.00
4	Latwadi 1 Top	7.63	3.59	24	Majrewadi	8.11	0.13
5	Latwadi 2	8.31	0.70	25	Kurundwad	7.71	0.30
6	Ghosarwad	8.49	0.57	26	Terwad	8.70	0.07
7	Dattawad 1	8.24	0.03	27	Herwad 1	7.55	2.63
8	Dattawad 2	8.03	0.09	28	Herwad 2	8.24	0.16
9	Mallikwadi	8.63	0.06	29	Kurundwad	7.46	0.50
10	Nave Danwad 1	8.40	0.06	30	Aurwad	8.90	0.09
11	June Danwad 1	8.16	0.06	31	Kavatheguland Mal	8.38	0.10
12	Nave Danwad 2	8.42	0.23	32	Kavatheguland 1	7.81	2.30
13	June Danwad 2	8.07	0.76	33	Kavatheguland 2	8.56	0.39
14	Takaliwadi 1	8.52	1.35	34	Shedshal	7.72	0.22
15	Takaliwadi 2	8.26	2.83	35	Ganeshwadi	8.69	0.14
16	Takaliwadi 3	8.41	0.24	36	Shedshalwadi	7.94	0.55
17	Takali	7.78	2.04	37	Kavatheguland 3	8.08	0.55
18	Rajapurwadi 1	7.32	0.80	38	Alas 1	8.13	0.10
19	Rajapurwadi 2	7.89	0.15	39	Alas 2	7.81	0.29
20	Khidrapur	7.26	0.39	40	Bubnal	7.94	0.09

The analysis reveals that for certain samples pH value ranges between 6.6 to 7.5. It is known as neutral soil. This category is found in Rajapurwadi, Khidrapur, Herwad and Narsobawadi village. Towards the northern part along the meandering course of Krishna River this area lies. This area is comparatively at higher elevation with respect to surrounding area. Hence, it is having natural drainage conditions to drain excess amount of irrigation water. Only four samples are falling in this class. All the samples show alkaline tendency of soil than acidic. pH value between 7.6 to 8.0 is known as Slightly alkaline Soil. This category found in Abdullat, Latwadi, Dattawad, June Danwad, Takali, Rajapurwadi, Rajapur, Kurundwad, Kavatheguland, Shedshal, Shedshalwadi and Alas village areas. This class contains 15 samples. Towards the eastern part this class is extended and it covers quite a larger area as per the statistical surface created through IDW technique. pH values between 8.1 to 8.5 is known as Moderate alkaline Soil. This categories found in Shiradwad, Latwadi, Dhosarwad, Dattwad, Nave Danwad, June Danwad, Takaliwadi , Takali, Majarewadi, Herwad, Kavatheguland Mal, Kavatheguland, Alas. pH values between 8.6 to 9 are known as Strongly alkaline Soil. This category is found in Abdullat, Mallikwadi, Bastwad, Terwad, Aurwad, Ganeshwadi.

EC statistical surface shows that majority of samples fall in low salinity category. EC values below 0.25 ms/cm are known as low Salinity category. This category is found in Shiradwad, Abdullat, Mallikwadi, Nave Danwad, Majarewadi, Terwad, Aurwad, Shedshal, Alas, and Bubnal village. Nineteen samples belong to this group. Towards the peripheral area of study region, this class dominates. Comparatively higher elevation, good drainage conditions and proximity of river is basically responsible for healthy conditions of soil.

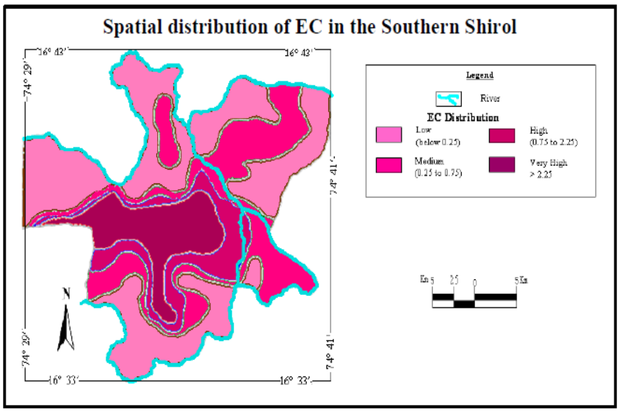

Fig.4. Soil Ec Distribution using IDW Interpolation.

EC values 0.25 to 0.75 ms/cm are known as Medium Salinity category. This category is found in Ghosarwad, Khidrapur, Rajapur, Kurundwad, Narsobawadi, Shedshal, Shedshalwadi and Alas village. Nine samples are falls in this category. EC values 0.75 to 2.25 ms/cm are known as High Salinity category. This category is found in Dattawad, June Danwad, Takaliwadi, Sainik Takali, Rajapurwadi, and Akiwat village. EC values above 2.25 ms/cm are known as Very High Salinity category. Seven samples are part of this category. This category is found in Latwadi, Takaliwadi, Herwad and Kavatheguland village. The middle part of the study region which is lacking in adequate drainage is basically much more degraded due to irrigation. The watertable is also quite high which makes this soil unsuitable for agriculture.

V. Conclusion

The degradation of soil in the study area is certainly caused by the anthropogenic activities. IDW interpolation techniques play a crucial role in generating continuous surface to assess saline soil conditions. In denudational slope area, the problem of saline soil is much prominent than surrounding area. The population of the study area is mainly engaged in agricultural activities. This cultivated area is under intensive farming. Particularly sugarcane has virtually mined nutrients from the soil and the problem of saline and alkaline soil has emerged.

Unscientific agricultural practices and irrigation methods, overuse of agro-input, frequent flooding of plain areas have caused degradation in the study region. This part is facing the problem of soil compaction and water logging. The soil in the region is mostly alkaline and saline. Lack of natural drainage, use of brackish water for irrigation, excessive use of chemical fertilizers and irrigation water, monoculture of sugarcane are some of the major causes for degradation of soil.

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