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Role of Soil Electrical Conductivity (EC) and pH in the Suitability Prognosis of Agricultural Practices in Noyyal River Basin

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Abstract

Impact of EC and pH of soil water on agricultural practices in Noyyal River Basin is reported. Soil Electrical Conductivity (EC) mapping is proposed as an inexpensive cum precision tool for farmers to adopt and characterize soil within their farm fields in addition to the pH profile of the soil. Its relationship to crop yield, salt concentrations and water-holding capacity and pH is elaborately studied to understand parameters like yield maps and yield variation.

Keywords: Mapping - Noyyal River Basin - Soil EC, pH

1. Introduction

The development of water resources in South Asian region for more than five decades, played a key role in stabilizing the production of agriculture and the reduction of scarcity [6]. This base, nevertheless, is in jeopardy to a large extent by increased competitions over restricted supplies and by the depletion/pollution of existing sources.

About 80-90 percent of freshwater resources is drawn by agriculture sector in India [2], [3], [5], [12]. Water quality forms a key environmental issue facing the agricultural practices in the present day. Ensuring appropriate quantity and quality of water for agriculture is, therefore, crucial for both food security and food safety.

While discharging effluent, the industries should consider the assimilative capacity of the land, failing which leads to pollution load and consequently pollutes groundwater and the soil [1], [10], [11].

Pollution, groundwater overdraft and rising competition over inadequate supplies make water a liable subject in the Noyyal basin, Tamilnadu. The basin was agricultural area earlier, irrigated through intricate networks of diversion weirs, tanks and canals [7].

The Noyyal River is a branch of the Cauvery. It is an interstate river traversing through the States of Karnataka and Tamilnadu and minimal time required for flows into the Bay of Bengal. It streams through the districts of Coimbatore, Erode and Karur (and currently formed Tirupur District) and the urban centres of Coimbatore and Tirupur. Industrial units like textile, chemicals and electroplating units situated in the river basin discharge effluents indiscriminately, treated or untreated, into the river. Sewage from Coimbatore and Tirupur cities is also discharged in several places into the river without treatment, creating the river as one of the highly polluted rivers in the country.

The Noyyal is a seasonal river. The river has fine flow during the North-East and South-West monsoons. When there is heavy rain in the region, occasional floods happen. The flow of the river is scanty almost throughout the year.

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The Noyyal river basin has a total area of 3510 km^3. (Location: between north latitude 10 56' and 11 19' and east longitude 76 41' and 77 56'). Noyyal River flows to a distance of about 170 km. The basin has an average width of 25 km. The entire Noyyal basin is located in Tamilnadu, encompassing parts of Coimbatore, Erode (including recently formed Tirupur District as well) and Karur districts. The Noyyal confluences with the Cauvery River at Noyyal village.

Several factors contributing to the decrease of agricultural production have been worked out. The present paper addresses the critical role of soil Electrical Conductivity (EC) and pH. They are mostly concerned with the pollution stress of different kinds, indiscriminate use of fertilizers and pesticides. However, the outcome of such studies is scant and the findings are piecemeal, making impossible, developing a holistic picture. It is well established that in addition to various chemical factors including the pollutants, several physical parameters have their own important roles in affecting the water and soil nature thereby, impacting grossly the agricultural production.

The ground water, surface water, soil and the natural ecosystem in Perundurai Taluk, Kangayam Taluk and Erode Taluk of Erode District and Aravankurchi Taluk and Karur Taluk of Karur District in Tamil Nadu, which form the study area, have been subjected to pollution to a great extent by the seepage and percolation of the pollutants of the River Noyyal in the past few decades; the insignificant effect of rainfall reduces the severity of the pollution.
The objectives are,

- To explore the quality of soil of nearby farmlands in areas located so proximally to the banks of river Noyyal, in Erode, Tirupur and Karur Districts of Tamil Nadu
- To understand the impacts of EC and pH of soil water on agricultural practices
- To document the ways and means currently chosen by the agriculturists to alleviate the difficulty of pollution
- To recommend solutions to counter the problems posed with by EC and pH of soil water.

2. Materials and Methods

The water quality in the Noyyal River Basin particularly in the Perundurai Taluk, and Erode Taluk, of Erode District, Kangayam Taluk of Tirupur District (erstwhile Erode District) and Aravankurchi Taluk and Karur Taluk of Karur District has been taken up and the two most important parameters EC and pH of the soil samples collected at different locations on the River course have been addressed to derive the probable relation to the fertility factor of the soil and the impact of agricultural practice in the study area.

2.1 Sampling Locations

The locations were selected for sample collection based on pilot surveys in Perundurai Taluk, and Erode Taluk of Erode District, Kangayam Taluk of Tirupur District, and Aravakurichi Taluk and Karur Taluk of Karur District. Adopting grid patterns soil samples were collected with a distance of 5 km to 7 km on either side of the river course for EC and pH analyses. The Electrical Conductivity and pH of the soils collected from different locations were found out using a Digital Conductivity Meter and Digital pH Meter Changes, if any, in respect of pH were cross checked using the Portable Digital pH Meter at the time of samples collections *in situ*.

2.2 Measuring Electrical Conductivity (EC) and pH with the Pour-Through Method [4]

The Virginia Tech Extraction Method (VTEM) or pour-through method was used. The VTEM method is adopted in view of its advantages over other methods for assessing Electrical Conductivity (EC). The advantages are,

- Sample extraction time is minimum
- EC and pH analysis is carried out in the land itself
- Involves no container medium
- Does not require specialized instruments for sample extraction
- Chance of rupturing slow release fertilizer materials is remote, thereby eliminating any false reading

2.3 VTEM Pour-Through Procedure

The container to be tested was placed on a PVC ring to keep the bottom of the container above the collection vessel. The collection vessel (8" dia saucer) was wide enough to collect all leachate. Distilled water was poured till the surface of the container medium (soil sample) so that approximately 50 to 60 ml of leachate could be collected in the vessel. About 150 - 175ml of distilled water per five liter container was adequate for the whole media. Five minutes were required time for leachate to drain from the container for collection. Uniform media Moisture content was ensured to be uniform. All samples were collected when the soil samples were with its maximum water-holding capacity (2 hours following irrigation). The collected soil water samples were subsequently analysed for EC and pH.

2.4 Timing

Soil samples were taken at regular intervals throughout the period of study. Care was taken to ensure that sampling occur at the same time in each area where samples are collected.

2.5 Surface and Subsurface Samples

Two samples were collected; a surface soil sample from the 0 to 8 inch depth, and a subsoil sample from the 8 to 24 inch depth.

2.6 Representative Sample

Each soil sample was ensured to be a composite consisting of the soil from core samples taken randomly at several places in the vicinity. This method of sampling is done to reduce the effects of any non-uniformity in the soil. Soil, from about 10 locations over the area, was taken for each soil sample. The soil cores were mixed thoroughly in large glass containers. Smaller apparently unusual areas were avoided.

Samples were collected during different seasons (*winter*: occurring from December to early March, the coldest months being December and January, and the temperature between 20°C and 25°C; *Summer or pre monsoon*: from March to June, hottest month being May, and the temperature between 30°C and 37°C; *Monsoon or rainy season*: from June to September; *Post-monsoon season*: from October to December) and the EC and pH values recorded to study the probable influence of rain in the area on these parameters and consequently agricultural practices.

During the various seasons of 2007-2009 spatial and temporal variation of soil electrical conductivity (EC) and pH were calculated in different layers across the field adopting Standard Methods using grid points.

The study spanned over a period of Two Years from February 2007 through February 2009 and the results pertaining to Perundurai Taluk of Erode District for 2008-2009 are given in the present paper and the rest will be presented in the subsequent papers.

3. Results and Discussions

Variations were observed in Electrical Conductivity (EC) and pH in the different Sampling locations and during different seasons of the year. The results are presented in Table 1 and Figures 1 to 7 depicting a probable common relationship between EC and pH among the different Sampling locations.

WHO has specified the standard value for EC at 1500 µS/cm (1.5 dS/m). EC of water is a direct function of its total dissolved salts and EC is therefore, to be considered a key to denote the total concentration of soluble salts in water in the study area. The electrical conductivity exhibited variations in the study area depending on the location and the season of study, and in many places the values exceed the WHO standard. The variation among the Sampling locations in any given season is notable. The reason may be ascribed to the indiscriminate discharge of the chemicals and salts used in the industries and subsequent leaching and percolation of these salts in the soil.

The studies revealed that EC values to fall in three categories (EC > 3 injurious; EC between 1.1 and 3.0- critical; EC < 1 normal). Of the three categories most of the EC values fall in two categories, injurious and critical in soil samples collected in close proximity in river course and near normal in locations away from 5Km to 7Km. In the same way, the pH of the soil samples collected in different locations in close proximity of the river course were found to exhibit tendency towards alkalinity (pH 8.5 – pH 9.0) in most places the pH was found to vary between 7.64 ±0.158 and 8.48± 0.862. In the monsoon season the pH values were found to vary between 7.84±0.136 and 8.32±0.181 and in the post monsoon period the pH values were found to be between 7.64±0.158 and 8.26±0.139. In both the monsoon and post monsoon seasons the pH values fall well within the defined value of less than 8.5 signifying greater tendency towards normalizing.

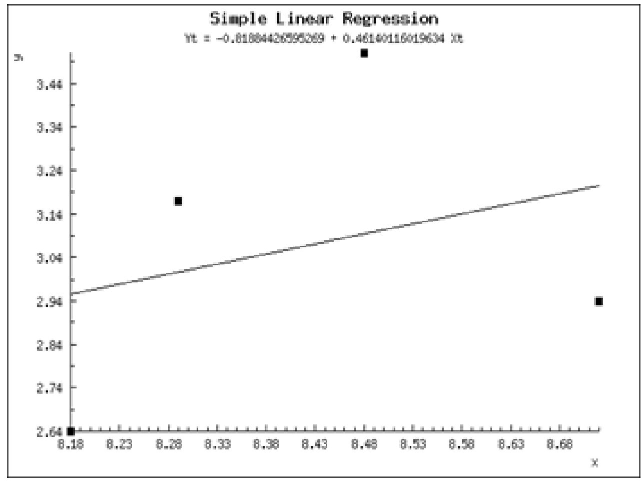
The ion-exchange reaction probably occurring between the exchangeable cations in the soil samples and the H^+ ions of rain could be the main causative factor for the increase of pH values of the soil water and the increase of cation profile of the irrigating water. This lends support as well to the condition of decrease of pH titre of soil-water samples and the reduced profile of the exchangeable cation concentration.

The nature of the soil and the varying flow properties of water as well should be considered to exert influence

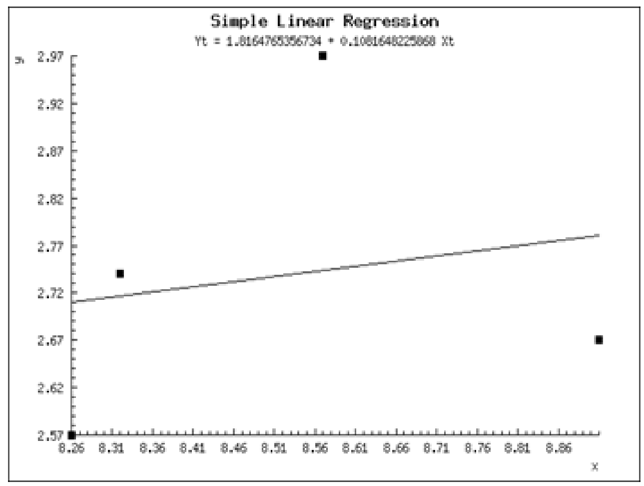
Table 1. EC and pH values of water samples collected at different Sampling Stations in Perundurai Taluk of Erode District during 2008 – 09

Sampling Station	Winter			Summer (Premonsoon)			Monsoon (South West Summer Monsoon)			Post Monsoon (Retreating Monsoon)		
	EC	pH	Status	EC	pH	Status	EC	pH	Status	EC	pH	Status
	EC/pH			EC/pH			EC/pH			EC/pH		
1. Morattupalayam	2.94±0.174	8.72±0.095	Critical/TA	3.51±0.168	8.42±0.073	Critical/N	3.17±0.091	8.29±0.173	Injurious/N	2.64±0.116	8.18±0.164	Critical/N
2. Anaipalayam	2.67±0.138	8.91±0.168	Critical/TA	2.97±0.135	8.57±0.142	Critical/TN	2.74±0.152	8.32±0.181	Critical/N	2.57±0.137	8.26±0.139	Critical/N
3. Kodumanal	1.94±0.086	8.48±0.862	Critical/N	2.14±0.158	8.12±0.171	Critical/N	2.08±0.174	8.01±0.145	Critical/N	1.52±0.152	7.94±0.153	Critical/N
4. Orathupalayam	2.86±0.158	8.81±0.118	Critical/TA	3.16±0.084	8.41±0.096	injurious/N	2.95±0.153	8.17±0.172	Critical/N	2.46±0.168	7.83±0.138	Critical/N
5. Ekattampalayam	1.58±0.142	8.63±0.127	Critical/TA	1.82±0.161	8.36±0.141	Critical/N	1.73±0.128	8.19±0.159	Critical/N	1.31±0.129	8.02±0.127	Critical/N
6. Pasuvapatti	1.73±0.893	8.51±0.154	Critical/TN	1.97±0.139	8.17±0.158	Critical/N	1.84±0.075	7.84±0.136	Critical/N	1.38±0.151	7.64±0.158	Critical/N
7. Kuppachipalayam	1.65±0.162	8.69±0.131	Critical/TN	1.85±0.147	8.48±0.149	Critical/N	1.76±0.142	8.16±0.185	Critical/N	1.36±0.148	8.07±0.146	Critical/N

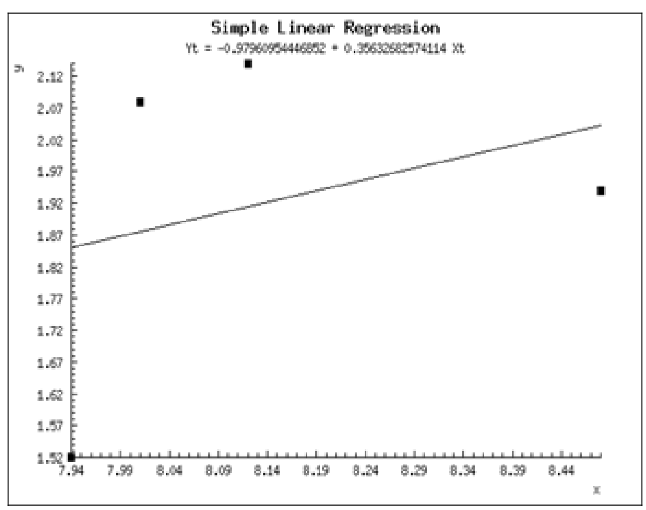
Values are Mean + S.E of 5 individual observations



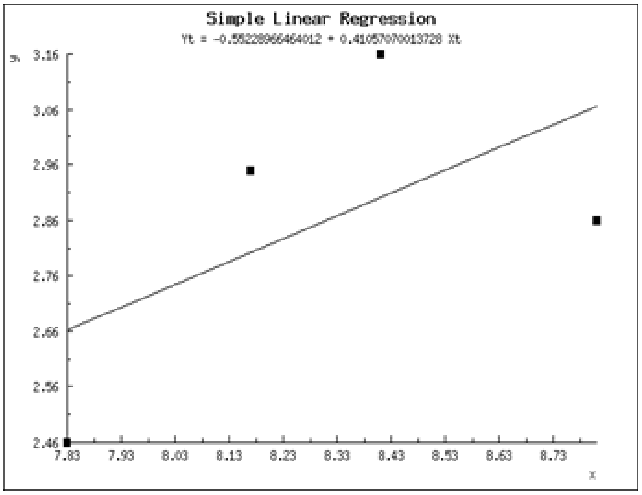
(**1**) Morattupalayam



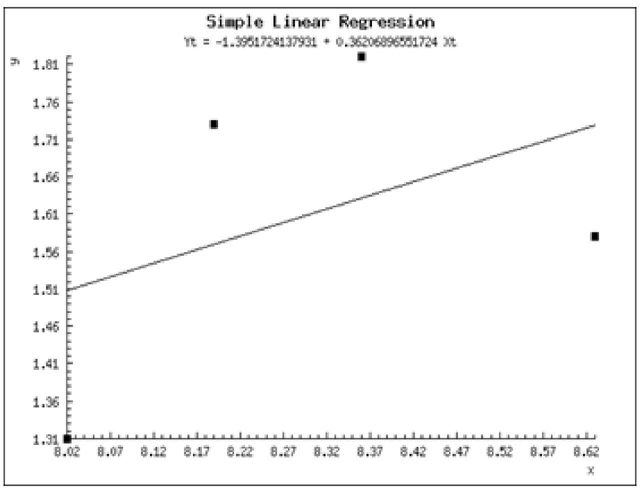
(**2**) Anaipalayam



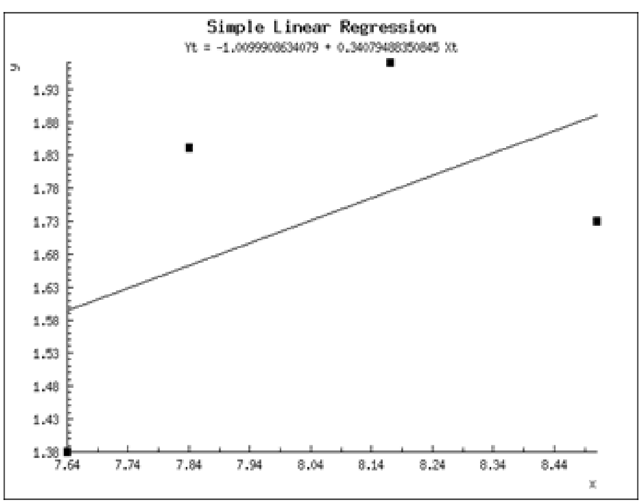
(**3**) Kodumana



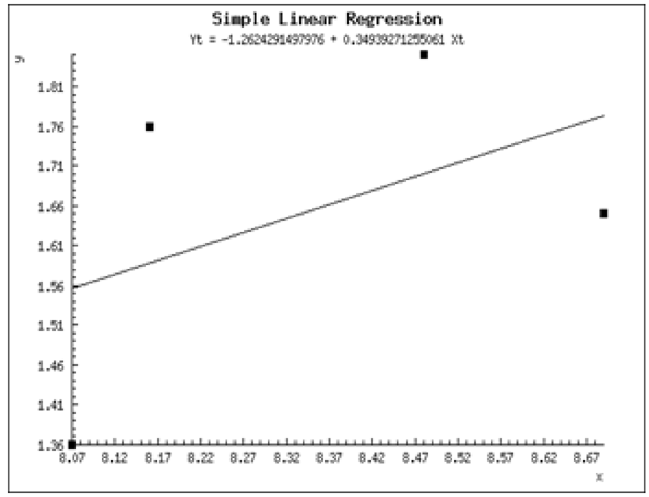
(4) Orathupalayam



(5) Ekaatampalayam



(6) Pasuvapatti



(7) Kuppachiplayam

Figure 1-7. Regression lines showing the relationship of pH (X-axis) and EC (Y-axis) in the locations studied.

Water EC		Soil pH	
0 – 1	Normal	Less than 8.5	Normal (N)
1.1 – 3.0	Critical	8.5 – 9.0	Tends to alkaline (TA)
Above 3.0	Injurious	Above 9.0	Alkaline (A)

on the EC and the concentration of available water soluble cations. These physico-chemical parameters are found to have been strongly affected by pH of rain in the present study in different sample locations. It is imperative, in view of this observation, to analyse in detail the geological properties of soil in the study area in relation to rain to gain an insight into the effect of rain.

EC has been widely reported to correlate with soil type differences and in terms of affecting both crop growth and productivity. In the case of non-saline soils, the soil water EC particularly, in respect of non-saline soils has been reported to mainly due to soil texture, soil water content and the water holding capacity and the dissolved ions level in pore water [9]. Rhoades and Corwin [8] have reported that EC increases with increased clay and water contents.

The saline-soil conditions in all the locations in the study area offer a different picture. The irrigating water rich already with salts owing to the pollution load and continued use more than a decade have rendered the increased soil EC more alkaline pH profile.

The seasonal changes in EC in the study area seemed to respond the changes in the soil volumetric water content and also to the soil temperature as is influenced by seasonal variations [Winter, Summer (pre-monsoon), Monsoon (South West) and post monsoon (North East Monsoon)], in the topsoil.

It is generally observed that rain normally should decrease the EC provided the moisture content remains unaltered. The spatial profile of both soil EC and pH were found to have been influenced considerably during the Monsoon and post monsoon periods. Further, the Soil pH is always considered to be a reliable indicator to denote the kind of nutrient problems to be expected in a soil. Subtle changes in pH as well are known to influence the tolerance level of several crops. pH profile tending to be alkaline in almost all the locations studied during winter needs specific attention. pH therefore indicates a possible problem that need to be investigated for the analyses. Soil electrical conductivity (EC) mapping developed from the data generated is an inexpensive simple tool of precision which can be used to characterize soil differences in the farming lands as EC correlates to soil properties affecting crop productivity, soil texture, cation exchange capacity, organic matter level and subsoil characteristics.

EC as a reliable measure specifies the presence or absence of salts. However it does not indicate explicitly the presence of salts. Increased EC level may be due to irrigation with salty water, the highly polluted load in the present study or it may be due to the field being recently fertilized and the elevated profile may as well from the soluble fertilizers. With exclusion of the later two probabilities and the area irrigated over long duration spanning more than a decade with much polluted river water it becomes evident that elevated EC titre is due mainly to the discharges let in to the river over its course.

It is well known that salt in the water normally reduces its water potential rendering it less available to the crop. The salt therefore, as a direct influence brings in water stress in the crop. The soil becomes more saline with the application of more salt in the irrigating water than is when the salt is not leached out or taken off by harvested plants then the soil water finally ceases to augment agricultural production.

Rainfall contains less quantity of salts and helps to dilute soil salts; sufficient the rainfall with appreciable amount and period of availability, and the soil having an internal drainage mechanism, the rainfall will be sufficient to percolate salts. In summer appreciable quantity of water is lost from the soil through evaporation and transpiration by the plants and salts get concentrated. In the present study it may be noted that the increased EC values during the winter and summer and a decline during the North East Monsoon and South West Monsoon could be considered as due to the rain water. This is evident in almost all the places where the study was carried out. It follows then that if irrigation water contains considerable salts, sequentially rigorous execution measure is essential to generate healthy plants. Consequently, EC measurement of the irrigation water source is a brilliant management assessment.

In the light of the foregoing the following recommendations/suggestions are made to augment the quality of soil water. Minimal levels for EC should range from 0.2 to 1.0 dS/m for ensuring proper crop cultivation. Maximum levels for most crops should not exceed 2.0 dS/m. Evaluation of soils for EC and pH at regular time interval will provide essential data on when the fertilizer, nutrient runs out, whether irrigation volume is enough or more. The EC readings could be used as part of their strategic planning for irrigation schedule.

Evaluating pH and EC of soil water well before cultivation and choosing the crops accordingly can ensure proper agricultural production avoiding plant loss. Such an exercise carried out with caution in the downstream area of Noyyal River Basin can bring back cultivation of several crops.

Currently rain fed cultivation is taken place sporadically in the above mentioned villages. Wet crop cultivation is limited enormously. Having soil water analyzed during hot and dry periods during the cultivation period is equally imperative as it is probable that EC can build up in the irrigation water; the EC may be mainly chlorides and sulphates, not the essential nutrients.

Land reclamation currently being followed with the Gypsum to Alkali soils (8.5 to 10.2) could be continued, with the EC and pH being closely monitored after such reclamation, and the crops suitably selected based on their sensitivity to EC and pH. An inventory on EC and pH will serve greatly agricultural practices in the Noyyal Basin and can be of use in similar situation elsewhere.

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