# APPLICATION OF FOURIER SERIES AND ARTIFICIAL NEURAL NETWORK IN PREDICTION OF SOIL TEMPERATURES.

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Annual range of the soil temperature at the depth 5 cm is the result of long-term thermal equilibrium between the soil and the atmosphere. During the warm season, soil temperature decreases with depth and the associated downward heat flux builds up the soil's heat store. In the season of winter the gradient is reversed and the heat store is gradually depleted. The spring and autumn are transitional periods when the ST gradients reverse the sign. These reversals are important biological triggers to soil pathogens, soil born insects and many other chemical activities. This shows the importance of soil temperature and so its estimation (Bocock, [1]) in Agriculture.

We have predicted the soil temperatures at three depths namely, 5 cm, 10 cm and 20 cm for morning and afternoon hours by using Fourier series (Carson, [2]; Kulshrestha, [6]) and Artificial Neural Network (ANN) algorithm techniques (Haykin,[5]; George, [3,4]). Anand station was selected for a case study. In ANN we have proved a convergence theorem for McChulloch (Mc. Culloch, [7]) type network. The proof is based on fixed-point theorem approach from functional analysis.

Prediction of soil temperature was carried out by two methods. These are

(I) Prediction of soil temperature by Artificial Neural Network with

(a) Three inputs, (b) Two inputs, (c) One input .

and

(II) Prediction of soil temperature by Fourier series (Harmonic Analysis (HA))

## CONCLUSION:-

Prediction of soil temperatures (ST) was made by ANN with different training methods. Different networks were used for each depths of 5 cm, 10 cm and 20 cm for morning (MN) and afternoon (AN) periods for the year 2004 and 2005. During this analysis the following conclusion has been made.

i) Obtained minimum Absolute Maximum Difference (AMD) & Root Mean Square Error (RMSE) and Percentage of error (PAE) are 4.67 $^0$C & 1.86 $^0$C, respectively in the year of 2004, at the depth 5 cm (MN).

ii) Fluctuation and variance (36.68 $^0$C) in the soil temperatures (AN) at the surface (5 cm) were high, therefore, during the prediction of soil temperatures for the year of 2005, computed Absolute Maximum Difference (AMD), Root Mean Square Error (RMSE) and PAE that were 10.68 $^0$C, 3.59 $^0$C and 8.98% , respectively were highest.

iii) Due to disturbance of the nature, like highest rainfall in the year 2005, in each case of each depth for morning (MN) and afternoon periods (AN),

2005 year has large Absolute Maximum Difference (AMD) & Root Mean Square Error (RMSE) in comparison to the other years.

iv) Each and every case of prediction by ANN with actual soil temperatures (ST) has large variations in the period of rainy days that is standard week from 22nd to 42nd.

v) All the predictions by ANN were significant to actual soil temperatures (ST).

Predictions of soil temperatures by HA for the year 2005 a the depth of 5cm afternoon showed in figure1. Though the harmonic analysis found to have less Root Mean Square Error (RMSE) and Percentage of Average Error (PAE) in comparison with ANN method, the difference is not significant. Here, RMSE and PAE were ranges by ANN from 1.86 $^0$C to 3.59 $^0$C and 6.39% to 8.98%, respectively. During the application of harmonic analysis found RMSE and PAE are ranges from 1.31 0C to 2.44 0C and 4.44% to 6.74%.

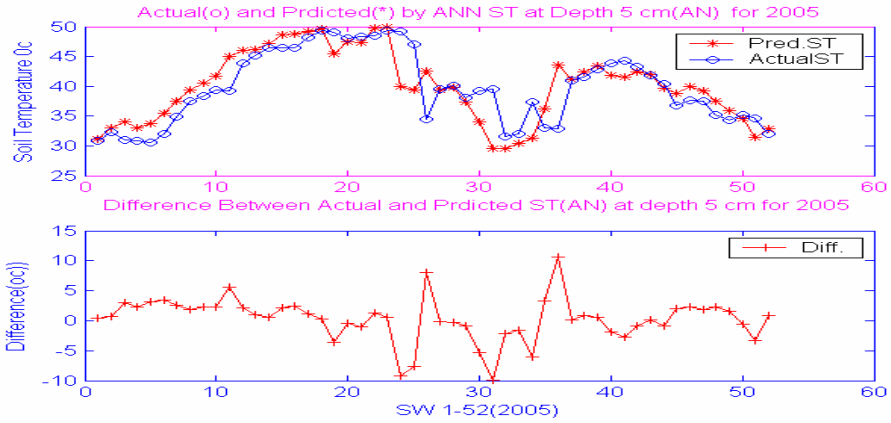


**Fig: 1**

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