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MODELING OF TRANSFER FACTOR FOR RADIONUCLIDE CESIUM (Cs) USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT
In this study, a Back Propagation Neural Network (BPNN) model with one hidden layer has been developed for transfer factor prediction to the tuber part of reddish. The input parameters to the developed model are soil properties. Exploratory data analysis has been performed to see correlation and select suitable soil parameters. The performance of Neural Network Model for transfer factor prediction has been compared with conventional Multiple Regression Model. Neural Network Model has been found more efficient in predicting transfer factor.

Keywords: Transfer Factor, Radionuclide, Neural Network, BPNN.

1. INTRODUCTION
Transfer factor is an important parameter for environmental safety assessment due to nuclear facilities. It can be defined as the uptake of radionuclide by a plant from soil. This parameter is crucial for several environmental transfer models, which are useful in the prediction of the radionuclide concentrations in agricultural crops for estimating dose impacts to man. Plants can be contaminated via three ways: root uptake, foliar absorption and surface adhesion of suspended contamination on leaves and stems [1]. Uptake of radionuclide by plants can be influenced by many factors [2]. For example, the availability of radionuclide in soils can be affected by soil moisture, cation exchange capacity (CEC), PH, percent organic matter, percent nutrients in the soil, and clay content etc. The great varieties of factors that can influence uptake, add considerable uncertainty to predicted values of vegetation concentrations.

The study has been performed to demonstrate the capability of Neural Network to predict transfer factor of radionuclide 137Cs. 137Cs is regard as an important radionuclide in radiology, because of their relatively high fission yields and influence on human health.

2. TRANSFER FACTOR MODELING
Conventional Model
Multiple linear regression method can be used to model transfer factor using soil property. It is a useful extension of least square method where dependent variable, Y is a linear function of two or more independent variables $(X_1, X_2, X_3 ......)$. The general form of multiple linear regression equation is

$$Y = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + e \quad (1)$$

Where B_0, B_1, B_2, B_3 are the coefficients and e is the error term. The best values of coefficient are selected in such a manner so that the error term reduces to zero. Under this study Multiple Linear Regression Model for transfer factor prediction has been developed based on least square method using soil PH, CEC, 40K, CaO, dry N_2, Ca and Cs. The obtained equation is (in normalized form)

$$\begin{aligned} TF &= 2.946871 - 7.375921468(P^H) - 0.93948(CEC) \\ &- 0.3094(^{40}K) + 0.93936(CaO) + 0.314976(dryN_2) \\ &+ 1.602599(Ca) - 0.18836(Cs) \end{aligned} \quad (2)$$

Artificial Neural Network
Artificial Neural Network has already become a useful tool for mathematical modeling of stochastic field as well as environmental engineering. There are many

applications of Neural Networks in environmental field such as in air particulate material prediction, oceanic model, water treatment etc.

Neural Network can function like a human brain [3,4]. It is trained with available data. During this training Neural Network gathers knowledge about the system and finally stores them as memory matrix. After completion of training, this memory matrix is used for prediction. Another important feature is that Neural Network is a data driven model. To work with a Neural Network, very detail knowledge is not necessary. It requires less input parameters with respect to conventional mathematical model. So, Neural Network can be used for inexpensive modeling.

The developed BPNN model contains one input layer, one hidden layer and one output layer and corresponding number of nodes are 8 (including bias), 3 and 1. Input parameters are soil properties (same as Multiple Linear Regression Model). Here additional input parameter bias has been included to expose the model with another additional degrees of freedom.

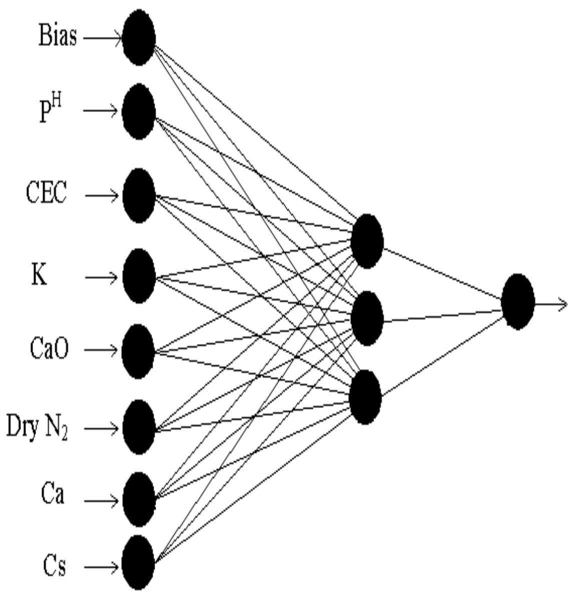

Fig 1. BPNN Model for Transfer Factor Prediction for Cs

3. RESULTS AND DISCUSSION

Beyond the number of hidden node 3, training error is relatively higher. So, the optimum number of hidden nodes is 3 (Fig. 2).

Training error reduces with epoch number (no. of trials). Under this study, it has been found that the developed Neural Network Model losses its generalization after epoch number 20,000.0. So, the optimum number of epoch has been fixed to 20,000.0 (training error, root mean square error =0.014445) to maintain the generalization of the model.

The developed Neural Network Model is capable to predict the most important input parameters to the model and they are dry Nitrogen and Cesium concentrations.

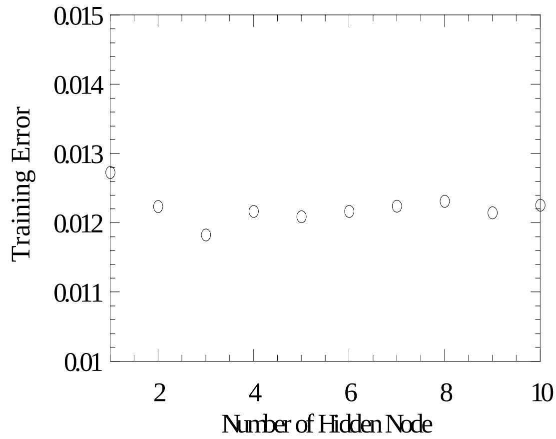

Fig 2. Training Error versus Number of Hidden Node

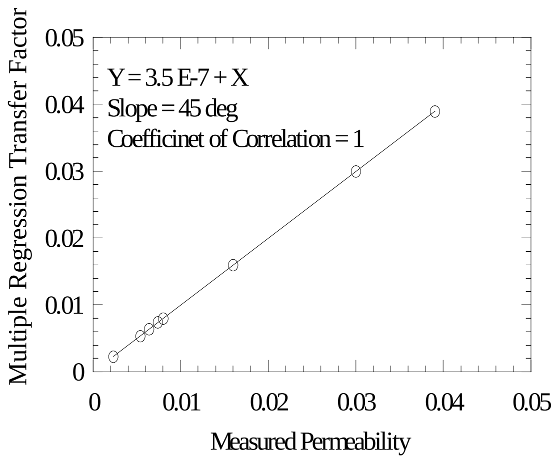

Fig 3. Transfer Factor Prediction (Curve fitting)

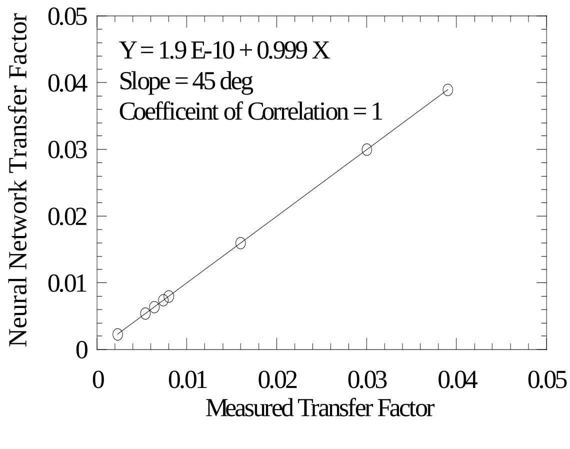

Fig 4. Transfer Factor Prediction (curve fitting)

The developed Neural Network and Multiple Regression Model provide acceptable results for good curve fittings (Fig. 3 and 4) but the latter failed to produce generalization (Fig. 5). So, the Multiple Regression Model is not capable to predict transfer factor for samples those are not used during the model development. On the other hand, Neural Network Model is capable to provide a steady generalization. Multiple regression's coefficient of correlation (in Fig. 5) has been found -0.209 while it is 0.97 (Fig. 6) for Artificial Neural Network, where 1.00 is a perfect match [5].

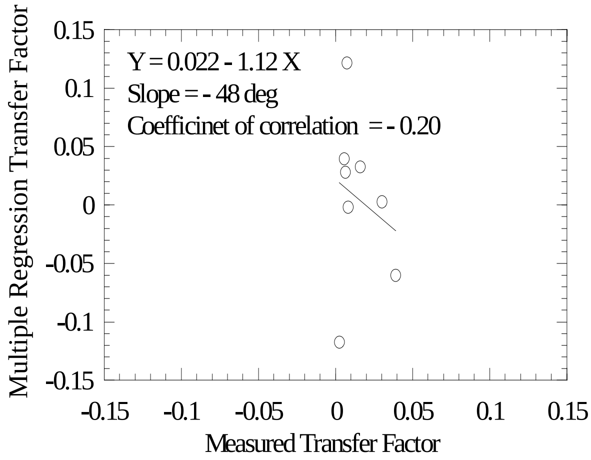

Fig 5. Transfer Factor Prediction Using Multiple Linear Regression Model

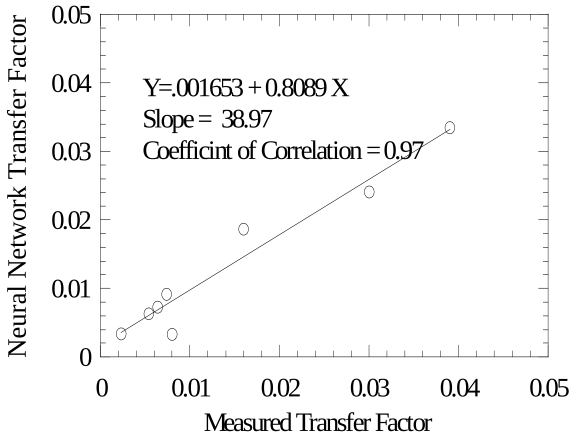

Fig 6. Transfer Factor Prediction Using Neural Network Model

4. CONCLUSIONS

It is possible to predict the transfer factor of radionuclide using Artificial Neural Network Model with more accuracy than conventional mathematical model. Outcome of this model is that it can be used to estimate transfer factor of radionuclide Cs for tuber part of radish if soil property is known.

5. FUTURE WORK

Under this study, transfer factor has been estimated only for a single plant. Here, we are ignoring soil type and concentrating only on soil properties. In a similar fashion, we can develop a generalized, cost effective and time saving model using soil and plant chemical properties ignoring the type of soil and plant.

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