Environmental Impact Assessments of Heavy Metal on Soil and Water for Coimbatore, India

A. GANDHIMATHI[1], A. ANBARASI[2]
[1]Department of Civil Engg, Kumaraguru College of Technology, Coimbatore, India
[2]Department of Computer Science, LRG Government Arts College for Women, Tirupur, India
Email: gandhimathi.a.ce@kct.ac.in, anbarasi2@gmail.com

Abstract: Coimbatore is the developing City in Tamilnadu and selected one of the smart cities in India. Coimbatore is under industrialization and urbanization on the positive side. Coimbatore become education Institutional hub and consists of lot of hi-tech medical centre but there is no proper drainage system in Coimbatore. Effluent from industry directly discharged in the soil that create soil pollution and water pollution. The assessment of heavy metal chromium (Cr), Iron (Fe), Mercury (Hg) concentration in soil and water in various places of Coimbatore was collected and experimented by using Atomic absorption Spectrometer. The ANN model was used to determine the heavy metal chromium (Cr), Iron Fe, Mercury (Hg) at new places. samples were collected in hundred places like roads, dumping yard, industry zone, domestic area and traffic area based on latitude and longitude .Maximum heavy metal are identified in wet land (Suggam and Sulur Lake, Traffic area (Gandhipuram), nearby electro plating industry (in Ganapathi)

Keywords: *Industrialization, ANN model, Heavy Metal Chromium (Cr), Iron Fe, Mercury (Hg)*

Introduction:

Coimbatore exhibits a rapid technical evolution in the state of Tamil Nadu, India. It is the second largest industrial center of the state. The major industries include textile, dyeing, electroplating, motor, pump set, foundry and metal casting. In fact, the present scenario edifies near about 500 textile industries, 300 electroplating industries, 300 dyeing units and 300 foundries in and around Coimbatore. Industrial effluents and municipal wastes contain either medium or maximum amount of heavy metals such as Chromium (Cr), Iron (Fe), Arsenic (As), Mercury (Hg), Cadmium (Cd)

Materials and Methods:

Artificial Neural Network Model

Back Propagation Algorithm

The back propagation is gradient decent algorithm and the term back propagation refers to the way in which the gradient is computed for nonlinear multilayer networks. The algorithm allows experimental acquisition of the input/output mapping knowledge within the multilayer networks. A neural network model was developed using the machining parameters as input to predict the constituents of the heavy metal in the soils such as , chromium, iron and mercury as output. The first step of the algorithm is to normalize the given input/output data to values between 0.1 - 0.9 by the following equation.

$$X_i = 0.8\frac{(Z_i - Z_{\min})}{(Z_{\max} - Z_{\min})} + 0.1$$

Where X_i = Normalized input/output value
Z_i = Actual input/output value
Z_{max} = Maximum input/output value
Z_{min} = Minimum input/ output value

Normalized values of input and output to neural model:

S. No	Input					
	Lat	Lon	Lea	Cr	Fe	Hg
1	0.15	0.72	0.15	0.22	0.109	0.489
2	0.16	0.72	0.11	0.20	0.193	0.100
3	0.33	0.73	0.10	0.17	0.421	0.100
4	0.30	0.64	0.13	0.16	0.360	0.114
5	0.26	0.18	0.31	0.76	0.119	0.181
6	0.25	0.69	0.28	0.78	0.207	0.100
7	0.28	0.18	0.16	0.54	0.225	0.100
8	0.25	0.69	0.34	0.14	0.771	0.100

Predictive network model for Chromium:

The feed forward three layered back propagation network architecture as depicted in the Fig. 1 was developed to predict chromium. The input layer consist of two nodes which represents latitude and longitude which used to predict the response and the output layer represents one node to receive response of chromium constituents. The number of hidden layers and neurons in the hidden layers had been determined by training several networks. Finally, 6 hidden layers and 20 neurons in each hidden layer had been chosen as optimum.

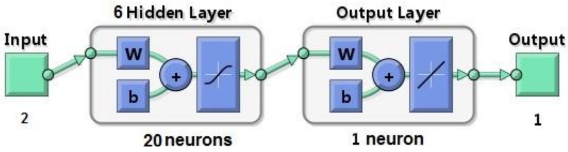

Figure 1: Prediction model for chromium

Neural network architecture to predict chromium

The network was trained for several times by fixing 1000 epoch to obtain the best validation performance. The best validation performance of mean squared error of 0.002561 was obtained at 138 epochs as subsequently stated in Fig.2 titled Network training to predict Chromium. The lower value of the mean squared error indicates the neural network model developed will predict better results.

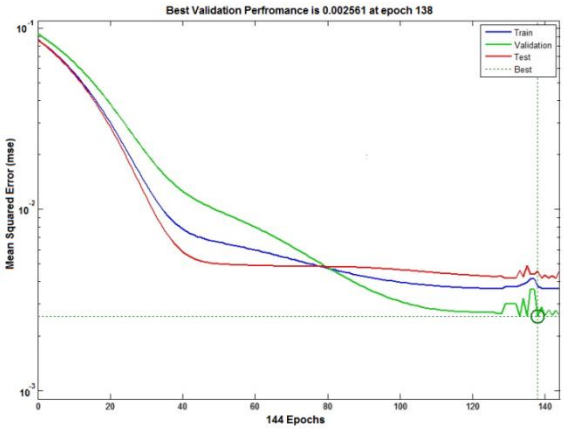

Figure 2: Network training to predict chromium

Predictive network model for Iron:

The feed forward three layered back propagation network architecture as depicted in the Fig. 3. Titled, Neural network architecture to predict Iron, is developed to predict the presence / composition or availability of the metal Iron(Fe). The input layer consists of two nodes which represent latitude and longitude which used to predict the response and the output layer represents one node to receive response to explore Fe constituents. The number of hidden layers and neurons in the hidden layer is determined by training several networks. Finally, 6 hidden layers and 10 neurons in each hidden layer are chosen as optimum.

The network was trained for several times by fixing 1000 epoch to obtain best validation performance. The best validation performance of mean squared error of 0.005472 was obtained at 93 epochs as shown in the Fig 4.0, titled, Network training to predict Iron. The lower value of the mean squared error indicates the neural network model developed will predict better result. The simulation results of the developed network from the network/data manager are then exported to the MATLAB workspace. The predicted values using this model are compared to the surveyed values at the final stage.The error percentage between the predicted value and surveyed was found to be less than 4% error.

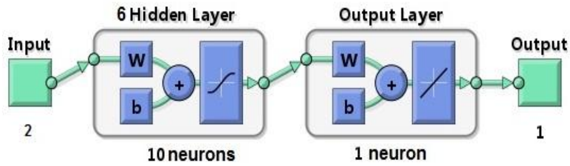

Figure 3: prediction model for Iron

Neural network architecture to predict Iron:

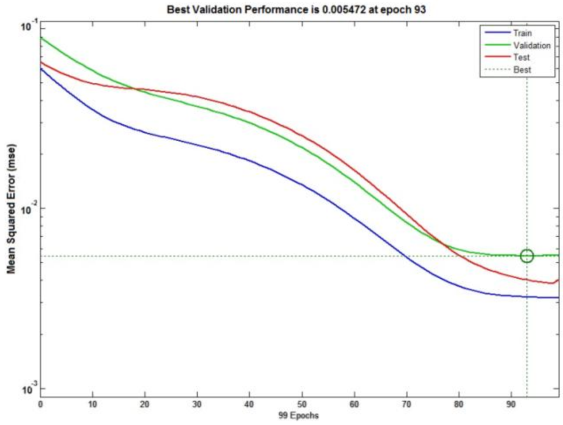

Figure 4: Network training to predict Iron

Predictive network model for Mercury (Hg):

The feed forward three layered back propagation network architecture as depicted in the Fig.5.0, titled, Neural network architecture to predict Mercury, (Hg), is developed to explore the presence / composition or availability of Hg. The input layer consist of two nodes which represents latitude and longitude which used to predict the response and the output layer represents one node to receive response Hg constituents. The number of hidden layer and neurons in the hidden layer has been determined by training several network, finally 6 hidden layers and 20 neurons in each hidden layer had been chosen as optimum.

The network was trained for several times by fixing 1000 epoch to obtain best validation performance. The best validation performance of mean squared error of 0.003622 is obtained at 99 epochs as shown in the Fig 6, titled, Network training to predict Mercury (Hg). The lower value of the mean squared error indicates the neural network model developed will predict better result. The simulation results of the developed network from the network/data manager are then exported to the MATLAB workspace. The error percentage between the predicted value and surveyed is observed to be less than 4 % error.

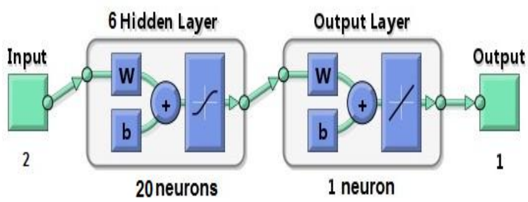

Figure 5: prediction model for Mercury

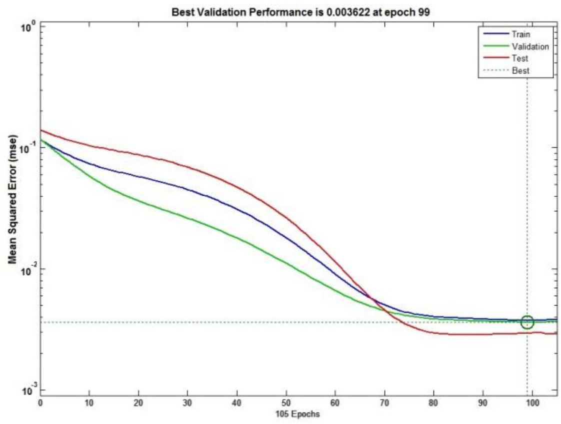

Figure 6: Network training to predict Mercury

Results and Discussion:

Confirmity Test

Generally, Confirmity Tests are performed to assure the quality of the materials taken for any study he data set consists of heavy metal constituents measured in the study area is used for modeling.. Presence of Cr varies from 0 to 3.6 ppm, maximum at Ganapathy and X - cut road exhibiting 3.6 & 3.5 ppm respectively. Presence of iron varies from 0 to 5.67 ppm. The maximum is explored at Pannimadai with 5.67 ppm. The presence of Mercury varies from 0 to 7.79. This is observed high in Sanganur road. The presence of Cadmium is severe at Sanganur whereas Town-hall shows proof for 2.04 ppm and 1.94 ppm.

Lat	Lon	M Cr	Pr Cr	M Fe	Pr Fe	M Hg	Pr Hg
11º12’88”N	76º 58’3.19”E	0.041	0.04	3.91	3.931	0.002	0.004
11º 2’44”N	76º 56’48.97”E	0.05	0.05	0.0980	0.0985	0.800	0.830
11º1’7.78”N	76 º 57’36.83”E	0	0	0.123	0.108	0.004	0.005
10º59’39.14”	76 º57’33.76”E	0	0	1.940	1.950	0.0024	0.004
11º 2’49.55”N	76º 59’18.20”E	3.467	3.468	4.140	4.141	0	0
11º1’51.30”N	77 º2’21.50”E	0.003	0.003	2.490	2.491	0	0
10º59’58.25”N	76º58’37.54”E	0	0	4.890	4.87	0.004	0.004
11º14’19.4”N	76º57’31.78”E	0	0	3.245	3.23	0	0
10 º58’53.91”N	77º5’18.69”E	0.677	0.675	3.230	3.22	0.987	0.987
10º59’44.51”N	76º59’0.95”E	1. 4	1.444	0.120	0.123	0.785	0.785
11º59’37.63”N	77º1’12.9”E	0.254	0.253	4.560	4.562	8.345	8.345

Samples of soil from discrepant locations in nd around Coimbatore which were not already tested as a part of this research were taken for a confirmity test. The recent samples were observed for the availability of heavy metals like, Lead, Chromium, Arsenic, Mercury, Iron and Cadmium through Atomic Adsorption Spectrometer. The above stated method edified the availability of heavy metal composition in the soil samples taken for the confirmity test. The results were then juxtaposed with that of the results observed through ANN Model for the availability of heavy metals like Lead, Chromium, Arsenic, Mercury, Iron and Cadmium studied in this research. The evident conclusion arrived through these tests exhibited approximately the same error percentage, (i:e; below 4%) as shown in table 3.8, titled, Confirmity test for ANN model. The closeness of the error percentage, 4%, observed through this ANN Model developed for this research is the best proof for the suitability of this strategy to find out the availability of heavy metals in the soil.

Conclusions:

- The capabilities of Artificial Neural Network model to predict heavy metal constituents in the study area has been researched and presented.
- Feed forward back propagation neural network model was developed to predict the constituents of the heavy metals in the soils such as Lead, Chromium, Arsenic, Iron, Mercury, and Cadmium using MATLAB 7.6 application tool.
- The input for the ANN model is considered as Latitude and Longitude of any specific point in the study area.
- The output from the model has been fixed as constituents of the heavy metals such as Lead, Chromium, Arsenic, Iron, Mercury and Cadmium.
- The precision of the ANN model was tested by conformity test and the results confirm that the accuracy of all the models is about 97%.
- The accuracy of the model can be increased by increasing the number of points taken within the study area for model development.
- During the development of models various network structure with varying the number of hidden layer and number of neurons in the hidden layer were analyzed to obtain best performance.
- Performance of the model developed has been validated by calculating mean squared error at various epochs. The lower value of the mean squared error indicates the predicting capacity of neural network model developed to obtain better results.
- The accuracy of the model has been verified by calculating the error percentage between the predicted value and surveyed value.

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