

A Survey on Application of ANNs in Solid Waste Prediction

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Abstract: Success of solid waste management system depends upon the prediction accuracy of solid waste generation in the city, hence it plays very important role in SWMS. This is a survey paper dealing with the use of neural network models for solid waste prediction. There are two types of prediction short term prediction and long term prediction mainly depends upon the data availability over the period of time. Artificial Neural Networks (ANNs) is become a key machine learning system in prediction area and proves that it is far superior to traditional statistical methods. Even though there is limited availability of data; artificial neural networks are competent of predicting waste generation with good results. Prediction of solid waste quantity for one particular city cannot be applicable to other study area due to different waste generating conditions belongs to that study area.

Keywords: Artificial Neural Networks (ANNs); Solid Waste Management System (SWMS); Neural Network (NN); Weekly Waste Generation (WWG); Solid Waste (SW).

I INTRODUCTION

Solid waste is useless material to be given out for disposal to Municipal Corporation. This unwanted material may contain food wastes, packaging in form of paper, metal, plastics or glass, discarded clothing, garden wastes, medicine waste etc. Solid waste can be generated through various areas like agriculture, industry and domestic. In case of domestic solid waste advanced society or urban areas produce larger solid waste where living of standard is very high as compared to rural areas.

In recent year solid waste quantity per capita is increases in urban area because of growth in urbanization, increase in economy and industrialization. Society is facing the serious problem of environment because of different types of chemicals, waste and air pollution. Now Indian cities generate eight times more MSW than 1947 because of increase in urbanization and change in life style [1]. The rate of increase of MSW generated per capita is estimated at 1 to 1.33% annually. By the year 2047, MSW generation in India, is expected to reach 300 MT and land requirement for disposal of this waste would be 169.6km² as against which only 20.2km² were occupied in 1997 for management of 48MT [2][3].

MSW generation rates in small cities are slower than those of metro cities, and the per capita generation rate of MSW in India ranges from 0.2 to 0.5 kg/ day. Total MSW generated by 217 million people living in urban areas was 23.86 million ton/yr in 1991, and more than 39 million ton in 2001 [4][8]. Because of improper disposal of MSW and its management, different types of pollution increases. Accurate prediction of solid waste generation is very important in the MSWMS. It is quite challenging to achieve the anticipated prediction accuracy with regard to the generation trends in many fast growing regions.

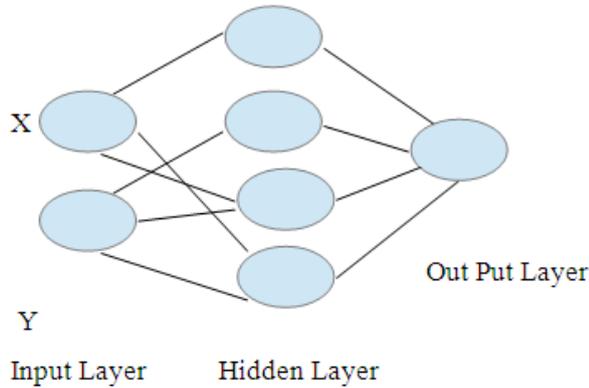
Economic trend, population, and quantity of solid waste under Municipal Corporation and their recycling are very important factor in the development of solid waste management system. One of the most difficult task in the implementation of waste management polices is the availability of information on factors contributing to waste generation.

II. ADVANTAGE OF ANN OVER DIFFERENT STATISTICAL METHODS IN THE SW PREDICTION

Many researchers had tried to predict the municipal solid waste using different statistical method for example Grossman [9] include the factor population, income level, and dwelling unit size in a single linear equation model. But the Dynamic properties in the process of solid waste generation cannot be fully characterized in those model formulations [29]. Chang, et al. [11] applied geometric lag econometric analysis, Khan and Burney (1989)[8] have established the influence of per capita income, population density, persons per house, GDP and population on the solid waste amount using linear regression.

But there are some limitations of statistical tools like Multiple Regression Techniques (Hair, Anderson, Tatham & Black, 1998)[22]. Time Series Analysis are good methodologies used for predicting the series, but the main drawback is that as the series become complex their forecasting ability is reduced, Kalyani Dacha (2007)[23]. Multiple regression analysis is another process can be used for prediction but such models can predict linear patterns only Mendenhall et al.[24]. Later on researcher favors NN because of its ability to model a nonlinear process without a priori knowledge about the nature of the process this is

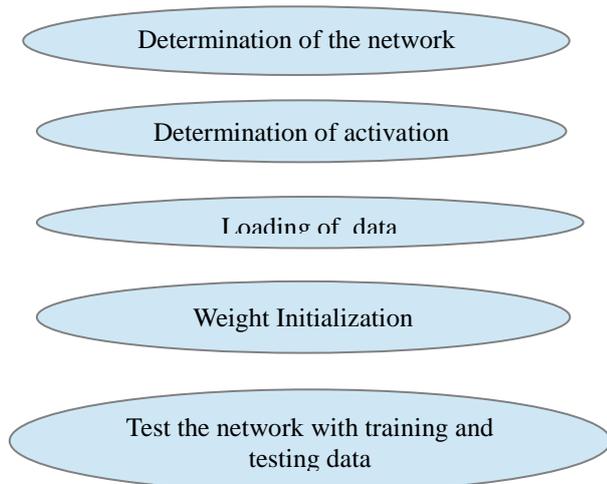
one of the advantages over the traditional statistical method. Artificial neural networks are nonlinear and uses estimation procedure like feed-forward and back propagation, where as traditional statistical model uses least squares or maximum likelihood.



Feed-forward ANN.

Additionally, neural network models do not require the same restrictive assumptions about the relationship between the independent variables and dependent variable(s)[20].

ANN models applied in many areas like medicine, business, insurance, stock market, and biology and computer science successfully because of their ability to capture nonlinear relationships associated with the use of non compensatory decision rules. In many predictive research problems it is proved that neural network models offer more predictive capacities over traditional statistical methods. Many researchers have attempted to predict municipal solid waste quantity using Artificial Neural Network. Training of neural network is the main step in the prediction. Following are some of the important steps to trained the neural network.



Prediction of MSW generation provides the basic data on which the management system is planned, designed and operated. Requirement of transportation trucks, segregation plant capacity, land requirement for composting, capacity of landfill site are directly depend on

quantity of MSW [16]. There are various factors involved in the generation of solid waste , Which causes prediction quite difficult .Also there is very high fluctuation in prediction of solid waste quantity. Neural network is beneficial in the problem in which future data can be predicted on the basis of previous data (training set).Now a day's use of neural network in prediction problem has been increase as compared to traditional linear models. The main advantage of neural network is that it is non linear in nature and helpful in understanding the data pattern and analysis of nonlinear system. ANN works on data. Neural Network architecture can be trained with known examples of problem so that it can identify new objects which are previously untrained. Neural Network can process information in parallel with high speed [21]. If we applied NN on non stationary and dynamic system then NN can change its network parameter (weights) in real time. This entire feature makes neural network better option as compared to other models in the prediction of solid waste.

III. EARLIER WORK

There are two types of prediction short-term and long term prediction. In short term prediction, prediction can be done on the actual last value. In long term prediction, predicted values can be reused to predict next future values. Short term and long term prediction mostly depend upon the data availability over the period of time. Nearly all the researchers have mentioned the problem of data availability. J. Sudhir Kumar, K. Venkata Subbaiah, and P. V. V. Prasada Rao[13] have mentioned the problem of data availability at study area. He uses RBF neural network for solid waste prediction.

RBFNN is mainly used for time series prediction. The data on various factors from 1961 to 2001 were considered. MSW in the study area was predicted around 39670 MT per year by 2026. Vatsal Patel[16] mentioned that due to non-availability of adequate data on waste generation for low-income cities of the developing countries, integrated solid waste management is very challenging. He uses a proposed model of Feed Forward Artificial Neural Network. Output generated for the previous years was taken as one of the input to ANN for the prediction of solid waste of next year. R Noori [19] MA Abdoli consider two forecasting techniques Multivariate linear regression (MLR), is based on principal component analysis (PCA) and a feed-forward multi-layer.

Weekly produced average solid waste and no. of Truck used for weekly solid waste collection were considered as factors. Result shows that ANN model has better results in comparison with PCA – MLR model.

Maleerat Sodanil & Paiboon Chatthong [26] uses Artificial neural network model .It was trained with back propagation algorithm. The results showed that the network structure of 3-35-1 performs the greatest performance with prediction accuracy at 0.870 and MSE equaling 0.2333. Jalili Ghazi Zade [17] had investigated

different structures of artificial neural network and then the best model for prediction of waste generation was chosen based on mean absolute error (MAE), mean absolute relative error (MARE), root mean square error (RMSE), correlation coefficient (R2) and threshold statistics (TS) indexes.

Also mentioned that artificial neural network model has more advantages in comparison with traditional methods in the prediction of solid waste generation.

Following table shows details of work done, various models used and their result.

Author , NN Model used & study area	Factor Considered	Result & Discussion
Sudhir Kumar [13]. Model used- A radial basis function. Study area - Eluru city, Andhra Pradesh India.	Four input variables are considered. <i>1. Population</i> <i>2. Percentage of urban population.</i> <i>3.GDP / capita.</i> <i>4. Generated MSW at corporation</i>	As past data was not available at municipal corporation he considered the data on national scenario i.e. as per census of India. Result shows projected MSW at Municipal Corporation Eluru for the year 2010 to 2026. And it was predicted around 39670 MT per year by 2026.
Vatsal Patel [16] Model used -A feed forward ANN neural network with one hidden layer of 3 neurons is considered. Study area -The no. of small towns of Gujarat state, India.	Factors like <i>1.Population of town during current year.</i> <i>2.Waste generation during current year.</i> <i>3.SC+ST population.</i> <i>4. Total received as tax.</i> <i>5.Longitude</i> <i>6.Latitude.</i>	Vastal patel[16] have mentioned the problem of non-availability of adequate data on waste generation for low-income cities of the developing countries, Population and waste generation are considered as dynamic variables and remaining variables assumed to be static variables. Performance of proposed ANN model is found to be satisfactory.
R Noori [19] MA Abdoli, M Jalili Ghazizade, R Samieifard Model used-Two forecasting techniques Multivariate linear regression (MLR), is based on principal component analysis (PCA) and a feed-forward multi-layer perception (ANN) was considered.	Weekly produced average solid waste, No .of Truck used for weekly solid waste collection.	Result shows that ANN model has better results in comparison with PCA – MLR model.
Mohammad Ali Abdoli, Maliheh Falah Nezhad, Reza Salehi Sede, Sadegh Behboudian [28]. Model used- comparison between the results of the multivariate regression model and ANN. Study area- Mashhad city	Population, household income, and maximum temperature are assumed as the effective factors on SWG in Mashhad.	Results indicate that multilayer perception approach has more advantages in comparison with traditional methods in predicting the municipal SWG.
Maleerat Sodanil & Paiboon Chatthong [26]. Model used- Time series forecasting model using artificial neural network. Study area - Bangkok city.	Amount of monthly solid waste was collected between October 2002 and July 2013, a total of 130 months gathered from the DOE.	Artificial neural network model was trained with back propagation algorithm. The results showed that the network structure of 3-35-1 performs the greatest performance with prediction accuracy at 0.870 and MSE equaling 0.2333.
Jalili Ghazi Zade, [17] Model used- Various structures of feed forward ANN with different number of neurons in hidden layer were investigated. Study area -Mashhad city.	Factors like Weekly produced average solid waste, and total Truck used for weekly solid waste collection.	He had investigated different structures of artificial network and then the best model for prediction of waste generation was chosen based on mean absolute error (MAE), mean absolute relative error (MARE), root mean square error (RMSE), correlation coefficient (R2) and threshold statistics (TS) indexes.

IV. CONCLUSION

This paper aims to make the survey of research work published on prediction of solid waste using artificial neural network. During study it is observed that

a) The nature of both type of prediction short-term prediction and long-term prediction are different as well. It is possible to predict the next week's solid waste with a maximum accuracy, while we cannot expect the next year's solid waste with the similar accuracy since the value of demographic and socioeconomic factor in per capita basis may be changed over the time.

b) According to literature survey population, socioeconomic and geographical area is important factors for prediction of solid waste.

c) Neural Network is better option in the prediction of solid waste than traditional statistical method. ANNs are significantly more accurate and it has an ability to extract information from large data set.

d) Though data availability is limited, still ANNs are capable of forecasting waste generation with good results.

e) Prediction of solid waste quantity for one particular study area cannot be applicable to other study area due to different waste generating conditions in that study area.

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