Time Series Forecasting of Solid Waste Generation in Karur City -Tamil Nadu

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Abstract
Statistical time series modeling is widely used in prediction and forecasting studies. This study intends to analyze, compare and select the best time series model for forecasting amount of solid waste generation for the next years in karur town – Tamil Nadu among ARIMA models by manual calculation and compared with the result generated by using software tool. The past data used are monthly amount of solid waste collected by the municipal authorities from year 2015 to 2017. Hence the solid waste generation can be predicted for the next upcoming years based on the past data.

I. INTRODUCTION
Solid wastes are materials of all sorts regarded as useless and are disposed. In urban areas there are disposal points in various locations for people to dispose. In this location, poor management of solid waste is a common phenomenon due to budgetary problems, mismatching plans and inadequate information about the amount of solid waste generated by residents, industrial activities and so on. Karur town in Tamil Nadu is one of the cities facing the problem of inefficient collection and disposal of solid waste. Population is among the major factors contributing to high amount of solid waste generation. Karur has a population of about 70980 increase out of which 34,937 are males and 36,043 are females thus the Average Sex Ratio of Karur is 1,032:with an average annual rate of about 4.32%. With this increasing population, if there is no proper measures taken to improve its management relative to the increasing population will lead to harmful consequences. Furthermore, there are no published figures of solid waste generation and their trend in karur. The uncollected solid waste in the town may also causes defects which include possible diseases outbreak and also blocks the city drainage systems bringing rise to other problems. This fact motivated this study of forecasting solid waste generation in the next five years so that karur municipal authorities can have useful information about the dynamics of solid waste generation to aid in their planning and operations.

The selection of a technique for prediction depends on many factors such as the accuracy desired, the relevance and availability of statistical data, the time period to be forecast, the cost/benefit of the forecast, easiness of interpretation and guidelines from the literature. In this paper, the forecasting is done by using statistical modeling technique ARIMA and also calculated using software (i.e.) MATLAB. The results generated are compared for better accuracy. Best suggestions are going to be provided for the study area for effective solid waste management to the municipality.

II. TIME SERIES MODEL
Initially, for choosing the suitable model it is necessary to undergo a Box – Jenkins approach. This approach involves about four stages before forecasting namely stationary checking, model identification, parameter estimation and diagnostic checking. The approach use historical data as it input to generate future values. The models’ work under assumptions that the data available are mean and variance stationary and the random errors or the difference between observed and forecasted values are uncorrelated. The statistical time series model used here is generally denoted as ARIMA (p,d,q) where parameters p, d, and q are the non-negative integers, p - order of the autoregressive model, d-degree of differencing and q-order of the moving average model. If the given data is non-cyclic, then the model is taken as auto ARIMA ( ).

III. PROCESS OF TIME SERIES FORECASTING
Time series analysis goes through specified set of procedures. Initially, plot a graph for the collected data. Then based on the ACF or PACF, find out whether the given data is stationary or non-stationary. Then identify the model technique that best suited for our forecasting. After that the model is to be built from the basic general regression equation as follows.

\[ y = a + bx \]

Where, \( x \) = explanatory variable, 
\( b \) = dependent variable, 
\( a \) = intercept.

The following equations are used to find a and b,
\[ a = \frac{\sum y(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2} \]

\[ b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \]

IV. TIME SERIES ANALYSIS

Data used in this forecasting were records of monthly amount of solid waste disposal collected for disposal from karur town by municipality of the district council from January 2015 to December 2018. A total of 36 observations are available which are used for model formulation and for model validation.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>QUARTER</th>
<th>WEIGHTAGE (KG)</th>
<th>t</th>
<th>4Q (MA)</th>
<th>CMA</th>
</tr>
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<tr>
<td>2015</td>
<td>Q1</td>
<td>8460525</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q2</td>
<td>9602280</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q3</td>
<td>9753170</td>
<td>3</td>
<td>9495164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q4</td>
<td>10164040</td>
<td>4</td>
<td>9818470</td>
<td>9656817</td>
</tr>
<tr>
<td>2016</td>
<td>Q1</td>
<td>9753750</td>
<td>5</td>
<td>9765853</td>
<td>9792161</td>
</tr>
<tr>
<td></td>
<td>Q2</td>
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<td>9644090</td>
</tr>
<tr>
<td></td>
<td>Q3</td>
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<tr>
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<tr>
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<td>8629140</td>
<td>8828713</td>
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<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>Q4</td>
<td>7986220</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table.1

Hence the table shows the solid waste collected for every month of 2015, 2016 and 2017 in kilogram. From the observation of the values, the minimum value is 2435890 kg in March, 2015 and the maximum value is 3553800 kg in October, 2015. The graph is plot between the amount of waste generated in Y-axis and year in quartile in X-axis. By examining the mean and variance of the data, it is found that the series is non-stationary, non-cyclic. The data of each year is split into 4 quartile and the calculation is processed. From the plot, it is observed that the given data in non-stationary. For that centered moving average line is plot in the time series plot graph.

Table.2

Then the mean and adjustment factor is to be found from the quartile values. The adjustment factor is based on the percentage of the centered average. Then the seasonal index is found which should be rounded off. For substituting into the formula, the total cumulative value of \( x, y \) and \( xy \) is to be calculated.

\[ \text{Adjustment Factor} = \frac{400}{400.321} = 0.9992 \]
5. SUMMARY AND CONCLUSION

The result is correlated based on the assumption that over a period of times the current values are related or correlated with their previous or ‘n’ previous values. Hence the result obtained at a quartile period of time. The current solid waste management presently handling in the municipality is as follows. 1. Collection details-House to House Collection by push carts and bins, 2. Segregation details-Segregation at source and segregation at site, 3. Storage details-Dumping yard, 4. Transportation details-Tricycle, Tractor, Trailer lorry, 5. Processing-Composting, 6. Disposal-Manure, Dumping. In future, due to the increasing population it is necessary to improve the system. The suggested idea is to design a proper landfill to the town. For that we choose a site in the karur and the selected the site having the facilities of composting yard, segregation unit, modern weigh bridge and it is located 12.2 km away from the town. The total area available is 24 acre. Out of these 15 acre is presently used for composting and the remaining 9 acre can be used for designing a landfill.

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