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.

1. 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.

2. 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 ().

2. 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,

$$a = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2}$$

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

3. Time series analysis

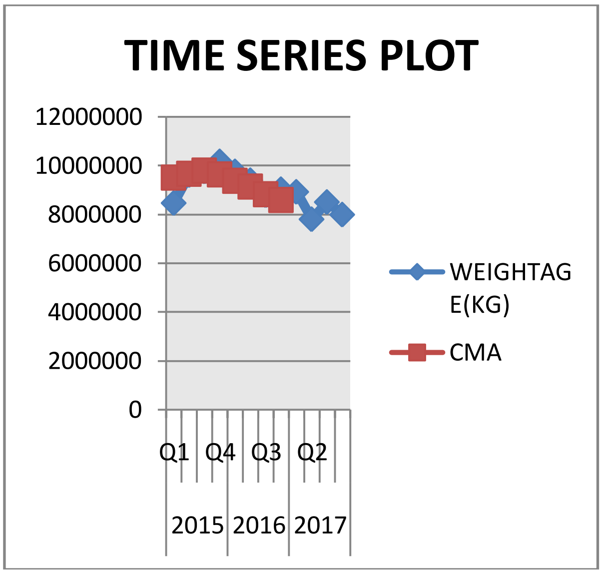
Data used in this forecasting were records of monthly amount of solid waste disposal collected for disposal from karur town by municipality of the district council from January 2015 to December 2018. A total of 36 observations are available which are used for model formulation and for model validation.

	2015	2016	2017
january	3346355	3274560	3059130
february	2678280	3012905	2708000
march	2435890	3466285	3150210
april	3027465	3202925	2591440
may	3334500	3174345	2742185
june	3240955	3015180	2462240
july	3179715	2937115	2685485
august	3256290	2939340	2893385
september	3317165	2902615	2921570
october	3553800	3053365	3301880
november	3267700	2986255	1648795
december	3342540	2984665	3035545
avg=	3165055	3079130	2766655

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.



YEAR	QUARTER	WEIGHTAGE(KG)	t	4Q(MA)	CMA
2015	Q1	8460525	1		
	Q2	9602920	2		
	Q3	9753170	3	9495164	
	Q4	10164040	4	9818470	9656817
2016	Q1	9753750	5	9765853	9792161
	Q2	9392450	6	9522328	9644090
	Q3	8779070	7	9237389	9379858
	Q4	9024285	8	9028286	9132838
2017	Q1	8917340	9	8629140	8828713
	Q2	7795865	10	8559483	8594311
	Q3	8500440	11	8299966	
	Q4	7986220	12		

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.

YEAR		Q1	Q2	Q3	Q4		
	2015			100.99%	103.80%		
	2016	101.14%	100.13%	96.13%	102.22%		
	2017	103.76%	92.48%				
MEAN		102.45%	96.31%	98.56%	103.00%	400.32%	400
X ADJ FACTOR		99.92%	99.92%	99.92%	99.92%	99.92%	
SEASONAL INDEX		102.37%	96.23%	98.48%	102.93%	400%	

Adjustment Factor = $\frac{400\%}{400.321\%}$ = 0.9992

X Code	Y	XY	X^2
1	84.605	84.605	1
2	96.029	192.058	4
3	97.531	292.593	9
4	101.64	406.56	16
5	97.537	487.685	25
6	93.924	563.544	36
7	87.79	614.53	49
8	90.242	721.936	64
9	89.173	802.557	81
10	77.958	779.58	100
11	85.004	935.044	121
12	79.862	958.344	144
78	1081.3	6839.036	650

$\bar{X} = \frac{78}{12} = 6.5$

$\bar{Y} = \frac{SUM\ (Y)}{12} = 90.108$

a = $\bar{Y}$ - b$\bar{X}$ = 90.108 – (1.32 * 6.5) = 81.49

Hence the final model formed for the prediction is as follows,

Y = 81.49 + 1.32(X)

4. Results and discussion

For predicting the future data, the X value should be changed according to the each quartile of the year. Here we are going to predict the value for up to 2025. So that the X value is from 13 to 44. The forecasted value for the year 2017 to 2025 is,

x		Y =81.49+1.32X
2015	Q1	82.81
	Q2	84.13
	Q3	85.45
	Q4	86.77
2016	Q1	88.09
	Q2	89.41
	Q3	90.73
	Q4	92.05
2017	Q1	93.37
	Q2	94.69
	Q3	96.01
	Q4	97.33
2018	Q1	98.65
	Q2	99.97
	Q3	101.29
	Q4	102.61
2019	Q1	103.93
	Q2	105.25
	Q3	106.57
	Q4	107.89
2020	Q1	109.21
	Q2	110.53
	Q3	111.85
	Q4	113.17
2021	Q1	114.49
	Q2	115.81
	Q3	117.13
	Q4	118.45
2022	Q1	119.77
	Q2	121.09
	Q3	122.41
	Q4	123.73
2023	Q1	164.3
	Q2	165.62
	Q3	127.69
	Q4	129.01
2024	Q1	130.33
	Q2	131.65
	Q3	132.97
	Q4	134.29
2025	Q1	135.61
	Q2	136.93
	Q3	138.25
	Q4	139.57

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.

6. References

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