EXCELLENT PUBLISHERS

International Journal of Current Research in Biosciences and Plant Biology

ISSN: 2349-8080 Volume 2 Number 5 (May-2015) pp. 108-112

www.ijcrbp.com

Original Research Article

Forecasting of Some Physical Parameters of Munj Sagar Talab Dhar (M.P.), India Using Holt Winter's Additive Method

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Abstract

Water is priceless gift of nature. The overall condition or health of aquatic ecosystem is determined by the interaction of its physical, chemical and biological components. Many methods and criteria are available to assess aquatic ecosystem. In the present study Holt Winter's additive method is used to forecast the transparency, turbidity and conductivity of Munj Sagar Talab Dhar (M.P.), India.

Keywords

Conductivity
Forecasting
Holt Winter's Additive method
Seasonal trend
Transparency
Turbidity

Introduction

Ponds are considered to be one of the most productive and biologically rich inland surface water eco-system. In order to protect the ecosystem, understanding of environmental changes are necessary. Ecological assessment helps us to conserve and manage natural resources. There are several statistical methods which may helpful in predicting and planning of the ecosystem such as Correlation, regression and cluster analysis. Correlation among the water quality parameters has been reported by Tiwari et al. (1988), Somasekhara Rao et al. (1994), Prakash (1994), Mariappan et al. (2000), Jeyaraj et al. (2002), Lingeswara Rao et al. (2002), Tyagi et al. (2003) and Mohanty et al. (2003). Systematic study of regression coefficients of the water parameters not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water and provide necessary clue for implementation of rapid water quality management programs (Dash, 2003; Mulla et al., 2007). Cluster analysis is a data analysis tool used to group data having similar charaectrestics (Prakash and Dagaonkar, 2011).

Forecasting facilitates us to evaluate some physico-chemical parameters of water body in advance without experimental determination

Materials and methods

About the water body

Munj Sagar is located in the district Dhar. It was excavated by Vakpati Munja (993AD), who was the famous rulers of Paramaras dynasty. Munja was a great general, a poet of repute and a great patron of art and literature. Munj Sagar Talab is geographically located at 22°30'06.67" North latitude and 75°17'42.67" East latitude. It covers an area of about 49.596 h. The altitude of Munj Sagar Talab is 554m. In Year 2005 it was deepen by removing the bottom soil. This water body was basically constructed for drinking water purpose but now-a-days its water is mainly utilized for irrigation and fish culture.

The collection of samples

The samples were collected in the first week of every month from November 2006 to October 2008 between 7 to 9 a.m. For the collection of water samples, iodine treated polyethylene bottles were used. All the precautions were taken to avoid air bubbles during the sampling.

Transparency

Transparency of water was determined with the help of Secchi-disc

Turbidity

Turbidity of water sample was measured by Systronics Turbidity meter.

Conductivity

The specific conductivity was measured by the conductivity meter which has a conductance cell containing platinum electrode coated with carbon.

Holt Winter's Additive method for forecasting

The Holt Winter's Additive method is applicable when the time series contains a seasonal component. This method assumes the time series is composed by a linear trend and a seasonal cycle, it constructs three statistically correlated series (smoothed, seasonal and trend) and projects forward the identified trend and seasonality.

$$\hat{Y}_{t+1} = \textbf{Estimated Level}_{t} + \textbf{Trend}_{t} + \textbf{Seasonal}_{t+1-4}$$

where we have:

$$\textbf{Estimated Level}_{t} = \alpha(Y_t - \textbf{Seasonal}_{t-4}) + (1-\alpha)(\textbf{Estimated Level}_{t-1} + \textbf{Trend}_{t-1})$$

$$\textbf{Trend}_{t} = \beta(\textbf{Estimated Level}_{t} - \textbf{Estimated Level}_{t-1}) + (1-\beta)\textbf{Trend}_{t-1}, \text{ and}$$

$$\textbf{Seasonal}_{t} = \gamma(Y_t - \textbf{Estimated Level}_{t}) + (1-\gamma)\textbf{Seasonal}_{t-4}$$

Alpha (α) = Smoothing parameter for the level component of the forecast. The value of alpha can be any number between 0 and 1.

Beta (β) = Smoothing parameter for the trend component of the forecast. The value of beta can be any number between 0 and 1.

Gamma (γ) = Smoothing parameter for the seasonality component of the forecast. The value of gamma can be any number between 0 and 1.

Y_t = forecasted value of variable at time 't'

Mean squared error (MSE)

The sum of the squared errors for each of the observations divided by the number of observations. For more accurate predication value of MSE should be minimum. The corresponding value of α, β and γ are chosen according to that particular parameter.

Results and discussion

The forecasting value of Transparency ,Turbidity and Conductivity are summarized in Tables 1 to 3. For more accurate predication value of MSE should be minimum. As the physico-chemical has a seasonal component, the Holt Winter's Additive method has

been used for forecasting. Holt Winter's Additive assumes the time series which is composed by a linear trend and a seasonal cycle. It constructs three statistically correlated series (smoothed, seasonal and trend) and projects forward the identified trend and seasonality (Figs. 1-3).

Table 1. Forecasting of Transparency using Holt-Winter additive method (α= 0.1, β= 0.05 and γ= 0.5).

Years	Seasons	Time	Observed Value	Base Level	Trend	Seasonal Factor	Forecast
2007	Winter	1	45.86	--	--	10.4	--
	Summer	2	28.18	--	--	-7.3	--
	Monsoon	3	32.40	35.5	0.00	-3.1	--
2008	Winter	4	44.38	34.2	-1.19	10.3	45.9
	Summer	5	27.85	34.9	0.59	-7.1	25.7
	Monsoon	6	33.58	36.5	1.51	-3.0	32.4
2009	Winter	7					48.3
	Summer	8					32.4
	Monsoon	9					38.1
2010	Winter	10	53.68	42.5	6.33	10.9	45.9
	Summer	11	34.99	41.4	-0.37	-6.2	43.3
	Monsoon	12	42.76	35.8	-5.07	7.1	48.6

Table 2. Forecasting of turbidity using Holt-Winter additive method (α= 0.1, β= 0.05 and γ= 0.5).

Years	Seasons	Time	Observed Value	Base Level	Trend	Seasonal Factor	Forecast
2007	Winter	1	14.69	--	--	-10.9	--
	Summer	2	34.72	--	--	9.2	--
	Monsoon	3	27.22	25.5	0.00	1.7	--
2008	Winter	4	14.20	25.1	-0.40	-10.9	14.7
	Summer	5	35.93	26.6	1.27	9.3	33.9
	Monsoon	6	27.72	26.2	-0.17	1.6	29.5
2009	Winter	7					15.2
	Summer	8					35.2
	Monsoon	9					27.3
2010	Winter	10	12.75	23.8	-1.57	-10.9	14.7
	Summer	11	31.76	22.6	-1.26	9.2	31.4
	Monsoon	12	26.98	21.1	-1.48	5.9	27.2

Table 3. Forecasting of Conductivity using Holt-Winter additive method (α= 0.9, β= 0.5 and γ= 0.5)

Years	Seasons	Time	Observed Value	Base Level	Trend	Seasonal Factor	Forecast
2007	Winter	1	229.50	--	--	-29.3	--
	Summer	2	259.25	--	--	0.5	--
	Monsoon	3	287.50	258.8	0.00	28.8	--
2008	Winter	4	227.33	256.8	-1.75	-29.4	229.5
	Summer	5	255.67	255.2	-1.66	0.5	255.5
	Monsoon	6	283.33	254.5	-0.78	28.8	282.2
2009	Winter	7					224.3
	Summer	8					253.4
	Monsoon	9					280.9
2010	Winter	10	227.14	256.6	-1.91	-29.4	229.5
	Summer	11	253.00	264.0	6.44	-11.5	242.7
	Monsoon	12	278.60	258.0	-4.73	21.3	292.4

Fig. 1: Showing observed and forecasted value of Transparency.

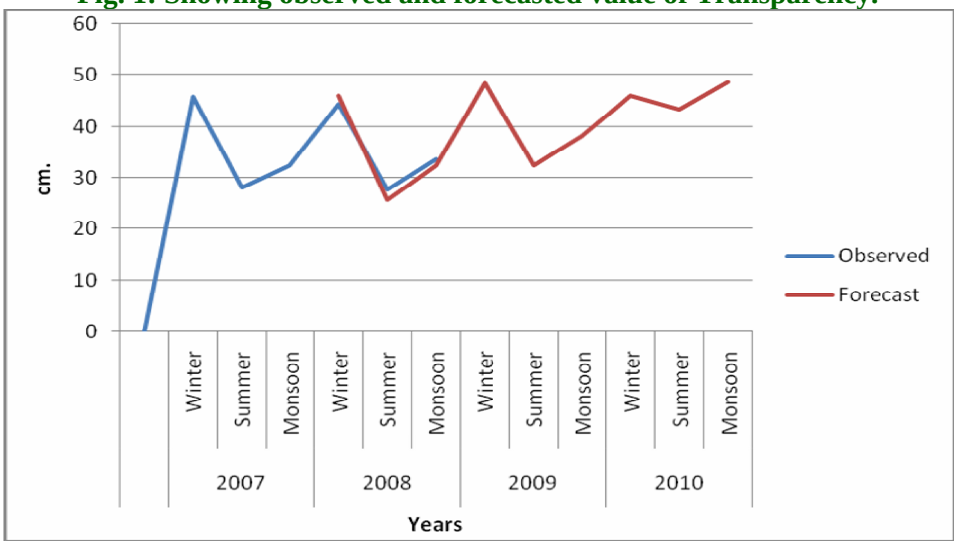


Fig. 2. Showing observed and forecasted value of Turbidity.

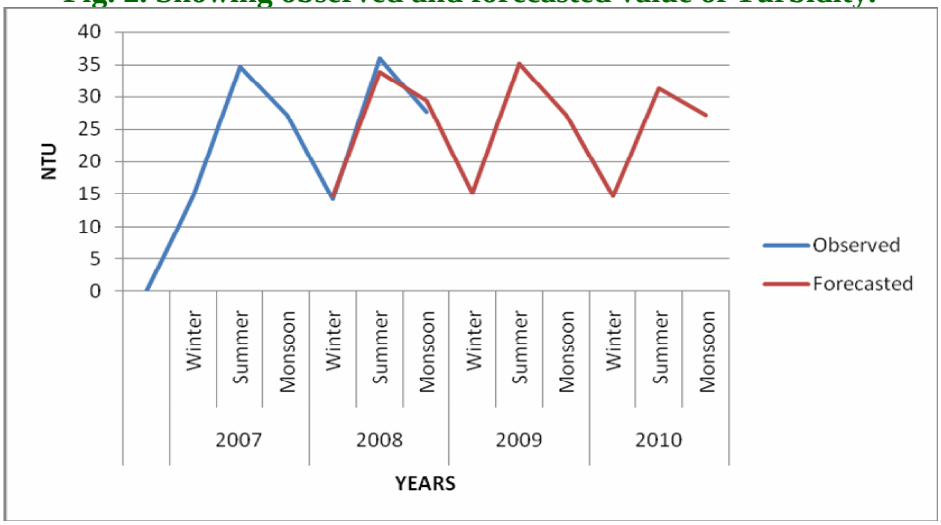
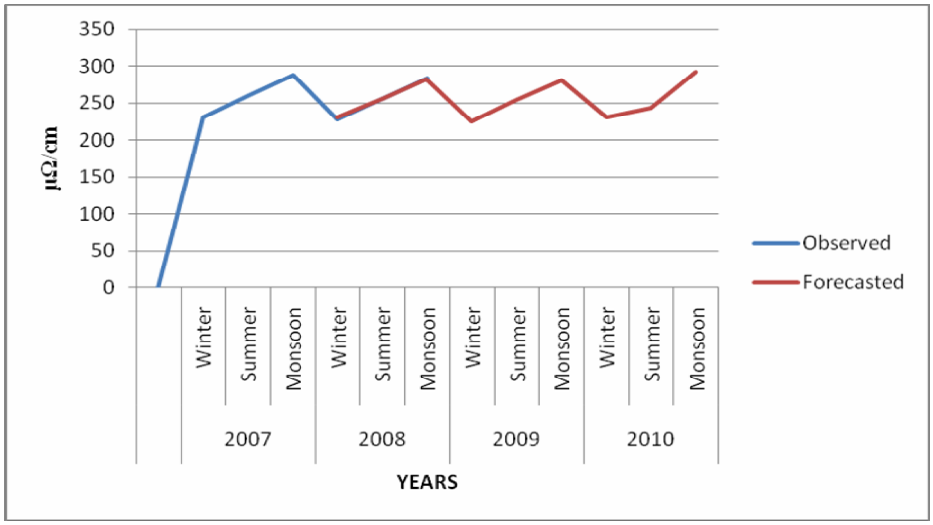


Fig. 3. Showing observed and forecasted value of Conductivity.



Holt Winter's Additive method requires at least two years of back data to calculate a forecast conventionally. Many fixed technique are being used for prediction of future time series data. It is observed in the present study Holt Winter's Additive method is highly effective and serve as powerful tool for future predication of time –series data. Beside this the present statistical work can be used further for the purpose of an adaptive ANN model for forecasting the water parameters of Munj Sagar Talab, Dhar.

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