Analysis of Inflow Time Series for Haditha Dam using Minitab Program

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ABSTRACT

The optimal exploitation of water from a dam reservoir requires a comprehensive knowledge of future availability of water resources. In this paper Haditha dam selected (is located on the Euphrates River, the provider of a modern city with 7 km, with an initial storage capacity of 8,28 billion cubic meters). An annual series of inflow discharge records are used for twenty one year from (1991 to 2011) with two month (January and Feb.), in this paper estimating a linear trend function and generate the random series of inflow discharge by using classical decomposition of the series. The Minitab program as used in the procedures of time series analyzing. The data and results were explained in tables and graphs.

Key words : *Minitab Program, Haditha Dam, Time Series.*

1. INTRODUCTION

A time series analysis is a valuable tool for obtaining information about analyzed data structures and their components, which provides a better foundation for future predictions in the event of success (Reyna and et. al. 2015). Dams were built in ancient times for a single purpose: water supply or irrigation. As civilizations advanced, there was a greater demand for water supply, irrigation, flood control, navigation, water quality, sediment control, and energy. As a result, dams are built for specific purposes such as water supply, flood control, irrigation, navigation, sedimentation control, and hydropower. Throughout the world, the demand for water is steadily increasing. There is no life above ground without water, our most important resource aside from air and land. Dams have served to ensure an adequate supply of quantity of water for nearly 5000 years by storing quantity of water in times of surplus and releasing it in times of scarcity, as well as preventing or mitigating floods. The majority of dams are single-purpose, but there are an increasing number of multipurpose dams. If dams are not properly constructed, there will be a severe disaster inside the dam's downstream regions. (Dogan, A., 2002).

The analysis of a temporally distributed sequence of data or the synthesis of a model for prediction in which periods are an independent variable is referred to as a time series model. Most statistical analyses of hydrologic time series for the typical periods scale encountered in water resource studies are predicated on the following fundamental assumptions: The series is homogeneous, stationary, and free of trends and shifts; it is non-periodic and has no persistence. (Naresh and Soorya, 2016). Time series models are used for forecasting or monitoring by recognizing the underlying forces and structure that produced the observed data. Time series analysis refers to statistical techniques that deal with time series data. The basic goals of time series are to illustrate the important features in which of the time series pattern, to capture how the previous affects the coming time, or how multiple time series can interact to forecast future values in which of the series. (Sara and Hanumanthappa,2017). The study aimed to analyze the behavior of inflow and outflow water through dams using periods series modelling and ARIMA modelling.

2. MATERIAL AND METHOD

2.1 The Case Study

The selected project is Haditha dam, one in which of the dams in which of Iraq, is located on the Euphrates River, the provider of a traditionally city with 7 km, with an initial storage ability of 8,28 billion cubic meters. In terms of it is contribution to electricity generation after the Mosul dam, the data used are an annual series of inflow rate of flow records are tried using for twenty single year from (1991 to 2011) in which for two months (jan. and Feb.)

Fig. 1 : Formation of Haditha Reservoir and site plan of the dam region (Google Earth)

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2.2 Methodology

2.2.1 *Time series structure*

For analysis the variation in the inflow rate toward the Haditha Reservoir, the data of the inflow rates that recorded in January and February months had been used to find out the correlation that reflected the behavior of trending in these data

The data used and the lags obtained were included in tables 1 and 2.

Table 1 : the inflow rates in January toward Haditha Reservoir (1991-2011)

	year T	1 شهر	inflow X_t	X_t*T	T^2
	1	1991	510	510	**1**
	2	1992	496	992	**4**
	3	1993	414	1242	**9**
	4	1994	486	1944	**16**
	5	1995	1286	6430	**25**
	6	1996	1169	7014	**36**
	7	1997	1056	7392	**49**
	8	1998	1132	9056	**64**
	9	1999	1013	9117	**81**
	10	2000	934	9340	**100**
	11	2001	310	3410	**121**
	12	2002	616	7394.76	**144**
	13	2003	663	8623.194	**169**
	14	2004	710	9946.323	**196**
	15	2005	925	13879.35	**225**
	16	2006	934	14939.87	**256**
	17	2007	1173	19933.87	**289**
	18	2008	879	15829.55	**324**
	19	2009	310	5890	**361**
	20	2010	350	7000	**400**
	21	2011	592	12438.77	**441**
∑	231		15959	172322.7	**3311**

Table 2 : the inflow rates in February toward Haditha Reservoir (1991-2011)

	year T	1 شهر	inflow X_t	X_t*T	T^2
	1	1991	**399**	399	**1**
	2	1992	**552**	1104	**4**
	3	1993	**358**	1074	**9**
	4	1994	**626**	2504	**16**
	5	1995	**1235**	6175	**25**
	6	1996	**1309**	7854	**36**
	7	1997	**1345**	9415	**49**
	8	1998	**1350**	10800	**64**
	9	1999	**945**	8505	**81**
	10	2000	**1187**	11870	**100**
	11	2001	**377**	4147	**121**
	12	2002	**391**	4687.2	**144**
	13	2003	**635**	8254.071	**169**
	14	2004	**1214**	17000.83	**196**
	15	2005	**859**	12885	**225**
	16	2006	**1313**	21008	**256**
	17	2007	**751**	12767	**289**
	18	2008	**758**	13644	**324**
	19	2009	**278**	5282	**361**
	20	2010	**405**	8100	**400**
	21	2011	**576**	12096	**441**
∑	231		**16863**	179571.1	**3311**

3. TIME SERIES ANALYSIS

For analysis the data under the time series techniques, a plot for inflow at each month was made under Minitab program. The time series plot for January and February months had been showed in Figure 2 and 3.

The next step was the founding of the autocorrelation for each month, the autocorrelation function was used to catch any bond in changing between the available inflow rate in each year. The autocorrelation graphs had been showed in Figure 4 and 5.

The forecasting data of inflow rates were evaluated by applying the autoregressive technique on the random variation of the inflow rates for January and February months. If the Y values are normally distributed, the partial autocorrelation between

Y_t and Y_{t-u} can be defined as

$Ø(u) = cor(Y_t, Y_{t-u}|Y_{t-1}, \ldots, Y_{t-u+1})$.

A more general approach is based on regression theory.

Y_t based on $Y_{t-1}, \ldots, Y_{t-u+1}$. The prediction is

$\acute{Y}_t = \beta_1 Y_{t-1} + \beta_2 Y_{t-2} \cdots, \beta_{u-1} Y_{t-u+1}$

It is also possible to "think backwards in time" and consider predicting Y_{t-u}

with the same set of predictors (Bras and Rodriguez-Iturbe,1985). The best predictor will be

$\acute{Y}_{i-u} = \beta_1 Y_{t-u+1} + \beta_2 Y_{t-u+2} \cdots, \beta_{u-1} Y_{t-1}$.

The formula obtained was applied on each data under the functions that built-in by Minitab program. the results were explained by the tables 3 and 4 and showed by the continued and dashed graphs in Figures 6 and 7.

For assigning more stability in forecasting the data of inflow rates, the errors that obtained from the difference between the actual and forecasted results of inflow were dealt under the technique of auto regression then the data had been reclaimed again to be as the dashed lines in Figures 8 and 9.

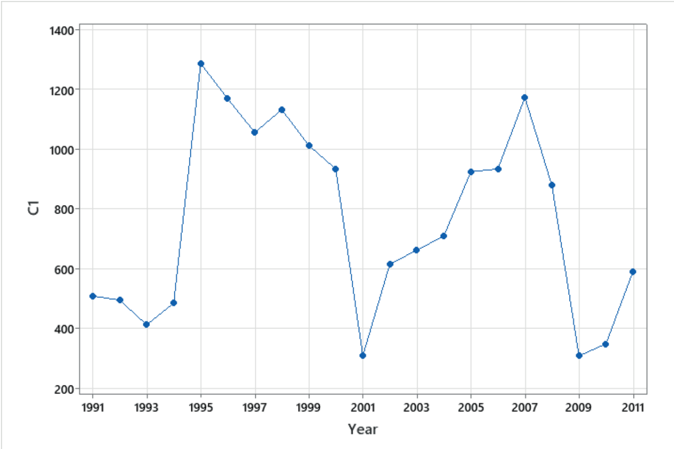

Fig. 2 : Time series plot for January month (1991-2011)

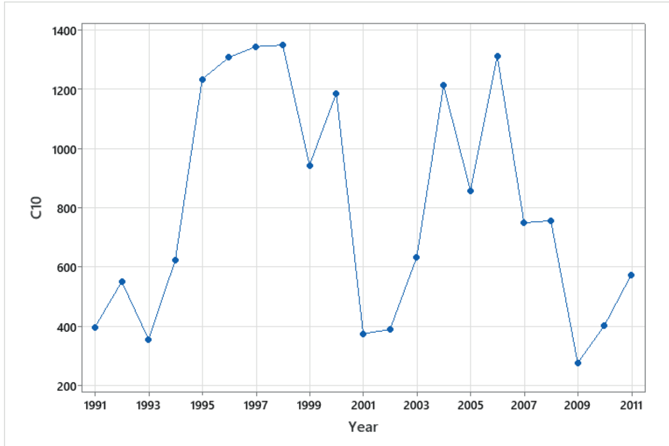

Fig. 3 : Time series plot for February month (1991-2011)

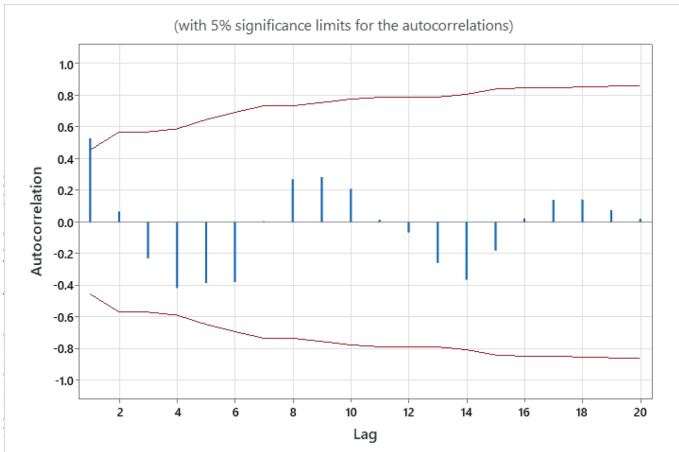

Fig. 4 : Autocorrelation output for January month (1991-2011)

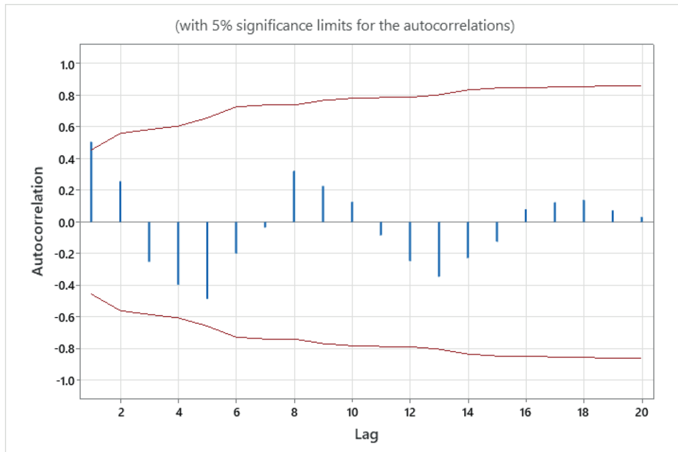

Fig. 5 : Autocorrelation output for February month (1991-2011)

Table 3 : the inflow rates in January (actual and forecasted) (1991-2011)

year T	شهر 1	inflow X_t	Forecasted X_t	e
1	1991	510	667.45	-157.445
2	1992	496	611.22	-115.218
3	1993	414	603.44	-189.440
4	1994	486	557.89	-71.888
5	1995	1286	597.89	688.115
6	1996	1169	1042.30	126.703
7	1997	1056	977.30	78.698
8	1998	1132	914.53	217.471
9	1999	1013	956.75	56.252
10	2000	934	890.64	43.358
11	2001	310	846.76	-536.756
12	2002	616	500.11	115.886
13	2003	663	670.10	-7.102
14	2004	710	696.21	13.789
15	2005	925	722.32	202.679
16	2006	934	841.76	92.244
17	2007	1173	846.76	326.244
18	2008	879	979.52	-100.524
19	2009	310	816.20	-506.203
20	2010	350	500.11	-150.114
21	2011	592	522.34	69.665

Table 4 : the inflow rates in February (actual and forecasted) (1991-2011)

year T	1 شهر	inflow X_t	Forecasted X_t	e
1	1991	**399**	658.37	-259.375
2	1992	**552**	566.45	-14.451
3	1993	**358**	650.44	-292.442
4	1994	**626**	543.94	82.056
5	1995	**1235**	691.06	543.936
6	1996	**1309**	1025.38	283.622
7	1997	**1345**	1066.00	278.999
8	1998	**1350**	1085.76	264.236
9	1999	**945**	1088.51	-143.508
10	2000	**1187**	866.18	320.819
11	2001	**377**	999.03	-622.029
12	2002	**391**	554.37	-163.374
13	2003	**635**	562.06	72.940
14	2004	**1214**	696.00	517.995
15	2005	**859**	1013.85	-154.850
16	2006	**1313**	818.97	494.029
17	2007	**751**	1068.20	-317.197
18	2008	**758**	759.68	-1.684
19	2009	**278**	763.53	-485.526
20	2010	**405**	500.03	-95.028
21	2011	**576**	569.75	6.255

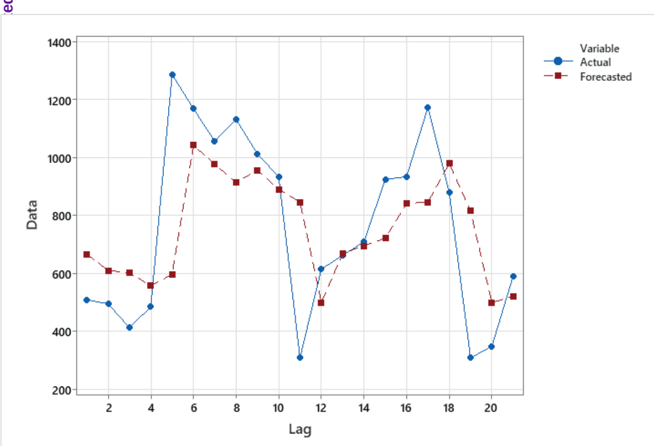

Fig. 6 : Time series plot for January month (actual and forecasted) (1991-2011)

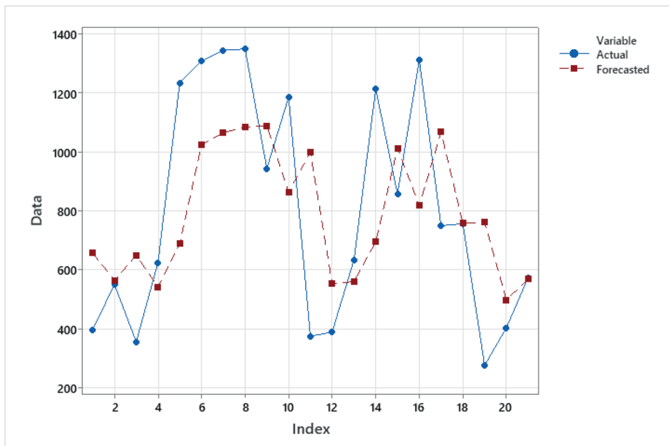

Fig. 7 : Time series plot for February month (actual and forecasted) (1991-2011)

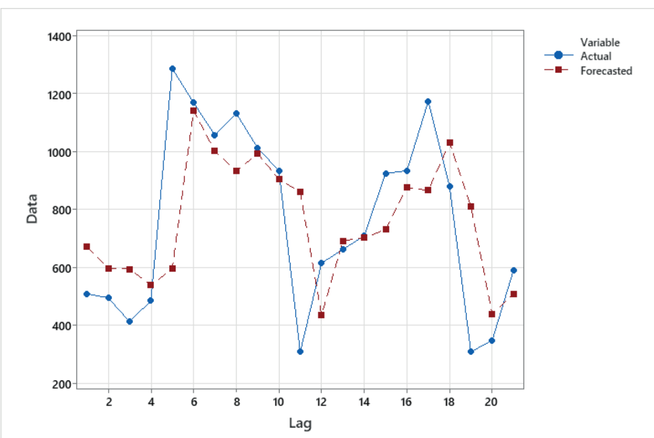

Fig. 8 : Time series plot for January month (actual and forecasted after AR of errors) (1991-2011)

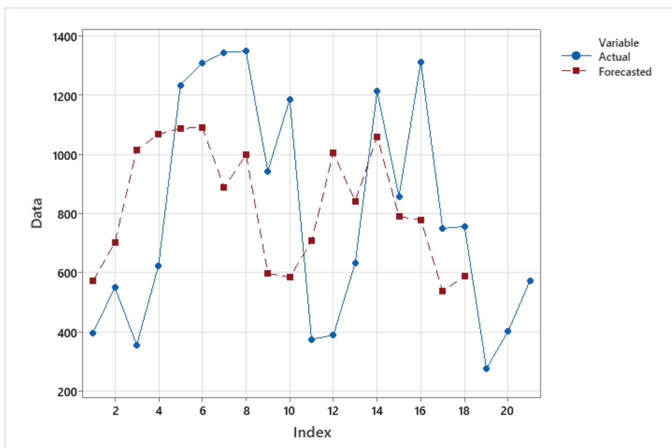

Fig. 9 : Time series plot for February month (actual and forecasted after AR of errors) (1991-2011

Table 5(a) : The inflow rates in January (actual and forecasted after AR of error) (1991-2011)

Year T	1 شهر	inflow X_t	Forecasted $error_t$	Forecasted X_t
1	1991	510	-163	673
2	1992	496	-102	598
3	1993	414	-182	596
4	1994	486	-54	540
5	1995	1286	690	596
6	1996	1169	28	1141
7	1997	1056	54	1002
8	1998	1132	200	932
9	1999	1013	20	993
10	2000	934	28	906
11	2001	310	-550	860
12	2002	616	180	436
13	2003	663	-30	693
14	2004	710	7	703
15	2005	925	193	732
16	2006	934	58	876
17	2007	1173	307	866
18	2008	879	-151	1030
19	2009	310	-500	810
20	2010	350	-90	440
21	2011	592	82	510

Table 5(b) : The inflow rates in February (actual and forecasted after AR of error) (1991-2011)

year T	1 شهر	inflow X_t	Forecasted X_t	e
1	1991	**399**	-274.392	673
2	1992	**552**	-43.067	595
3	1993	**358**	-309.492	667
4	1994	**626**	51.879	574
5	1995	**1235**	531.442	704
6	1996	**1309**	292.937	1016
7	1997	**1345**	276.023	1069
8	1998	**1350**	261.042	1089
9	1999	**945**	-147.400	1092
10	2000	**1187**	297.674	889
11	2001	**377**	-623.248	1000
12	2002	**391**	-209.114	600
13	2003	**635**	48.858	586
14	2004	**1214**	505.071	709
15	2005	**859**	-146.759	1006
16	2006	**1313**	470.349	843
17	2007	**751**	-310.238	1061
18	2008	**758**	-33.029	791
19	2009	**278**	-501.974	780
20	2010	**405**	-134.322	539
21	2011	**576**	-14.600	591

4. CONCLUSION

The inflow rates information toward the Haditha reservoir for January and February months in period (1991 to 2011) had been used to build time series analysis and examining of the behavior of data according to state of variation. The data showed high random variation for the two months as showed by the autocorrelation graphs that built by using Minitab program. Auto regression technique was applied to the data and the results were explained in related graphs. For gaining more precious in data variation system, the error was then considered in time series and auto regression was made to identify the new error distribution along the inflow rates data. The new inflow rates then calculated and graphed. The double auto regression reclamation showed better closing from the forecasted data and the actual data that can be very noticeably in the range of years (1997 to 2001) and the range (2005 to 2007). The variation in the inflow rates in these two months reflected the high accumulation of water feeding that coming from the weather condition(rainfall intensity) as well as the inflow rates from the Euphrates river.

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