Depth analysis of Jimeta Bridge section of river Benue, Nigeria

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Abstract

This study analyses the depth of river Benue at Jimeta Bridge, Yola Nigeria. The data used for the study was obtained from Upper Benue River Basin Development Authority Yola Adamawa State. Simple linear regression equation was used to fit the trend line, from which a time series table was produced showing the trend, a time series graph was also produced to show how the level of water varies with time. The Durbin-Watson d statistics was used to test for the presence of first order autocorrelation. By using the least squares in performing the analysis, it was noticed that the value of the trend (Y_t) increases steadily at a regular pattern from 2.28646581 to 292.6676237 showing that there is variation in the depth of the river with time. The time series graph shows that from January to June usually have the minimum height, while July to November usually have the highest level of water. It is therefore recommended that analysis of the depth of the river be carried out periodically for future forecasting, this will caution against over flooding or drying of the river.

Keywords: Time series, Ordinary Least Squares, Durbin-Watson

Introduction

River depth is an important hydrographic data and is a useful tool in providing answers to some of the problems confronting river engineers in dredging, construction and management of hydraulic structures, such as dams, bridges, pipelines, irrigation scheme e.t.c. Analysis of the river depth gives a clear picture on the annual behaviour of river and nature of the underwater surface. Hashidu (1987), opines that comprehensive analysis and study of river basin is generally recognised as a basic necessity for healthy growth of a country, and depth analysis is a major aspect of investigation of a river. An analysis of river depth was carried out in order to determine the minimum depth in the navigational channel of st Mary's river. Aaron (2010), reported that the Bathymetric soundings of St. Mary's river were imported and used in an ArcGIS package in conjunction with a triangular irregular network (TIN) models created to identify points of minimum depth.

Required data for depth is also important for marine geologist, marine biologist and environmental scientists. The growing need for adequate water supply coupled with serious problems of rapid desertification in certain part of the world has sharply attracted man's attention to the location and control of water resources (Kalitsin, 1973). In their work Mishra and Sim (2010), discovered that the transmisivity constant depends on the depth of water in the river and the distance of the observation well from the river bank. Also in their quest to discover the hydrogeologic and water quality characteristics of river benue, Gabriel and Donatus (2010), uses the static water level data obtained from the upper benue river basin development Authority.

Hydrographic surveying is the branch of survey that determines the depth and level of water it also deals with the determination of relative positions of the different points on the underwater and near water surface. It is the science of measurement and description of features which affect maritime navigation, marine construction, dredging, offshore oil exploration/drilling and related disciplines (Wikipedia 2010). Such surveys are employed in mapping the characteristic features on the underwater and near water surface, and recording the necessary observations relevant to the objective of the survey.

Several methods are used in the determination of water depth in a river in hydrographic surveying. Nguyen et al (2004), uses a real time kinematic (RTK) technique of a Differential Global Positioning System to determine the water level at sea. It was discovered that RTK can best be applied at complicated areas like coastal areas of the sea in which the distance between the base station and the rover station is up to a kilometre. Also in their work to determine the topography of river surface, Denis et al (2011), proposed an application of two techniques; radiometric models and through-water photogrammetry with very high resolution, passive optical imagery, high plat forms and off the shelf cameras. They study revealed that in the case of the radiometric models, measurement is possible with a special filtering of about 1 meter and a homogeneous river bottom. In contrast with through-water photogrammetry fine resolution and bottom texture are necessary.

The Upper Benue River Basin has a dynamic behaviour ranging from sedimentation, seasonal fluctuation and flooding and this possess serious threat to human lives and properties especially when it overflow its bank. An understanding of the behaviour of the groundwater body and its long-term trend is essential for making any management decision in a given watershed (Raghunath et al 2005). Frequent analysis has to be made at regular interval to understand the behaviour of the river and its long term effect on the surrounding environment. Over the years attention has been concentrated in the area of water level variation, discharge and depth of River Benue as reported by the Upper Benue River Development Authority (UBRDA). Little or no work has been done towards analysis of the depth of the river at Jimeta Bridge. It is on that note, that this study was conducted to investigate the highest level of water depth in the period under review and also produce a time series graph showing the variation of water with time.

Materials and Methods

The study area is Jimeta in Yola North Local Government Area of Adamawa State. Jimeta is situated between latitudes 9°11’N to 9°20’N and longitudes 12°23’E to 12°33’E. The area has a mean annual rainfall of 918.9 mm, and monthly minimum temperature of 19°C and maximum temperature of 37.9°C. The mean monthly temperature is 28.5°C (Ishaku, 2007). The area is largely drained by the River Benue, which is characterized by extensive flood plains along which occur lakes Geriyo and Njuwa (Adekeye and Ishaku, 2004). Jimeta area is bordered by River Benue and lake Geriyo and is dissected by a number of small streams. The major occupation of the people is agriculture. The population of the area is about 325,925 based on 2006 population census. Jimeta Bridge lies accros the river Benue along Mubi road. Depth analysis of any data, which always involved a trend change in such data with time if correctly analyzed using the appropriate statistical method, will help in forecasting the occurrence of such event (Ingham, 1992). Data used for the analysis was the monthly mean gauge height obtained from the Upper Benue River Basin Development Authority Yola as shown on table 1 below. The data was processed in order to produce a time series table which was later used for the analysis of depth of River Benue at Jimeta Bridge. The mathematical and statistical formulations were derived from Francis et al (2004) and Dominic and Derrick (2002)

Let; $Y_t = \alpha + \beta X_t + e_t$................*(1)*

Where; Y_t - Dependent variable (the regression)
X_t - Ingredient variable (the explanatory)
α - A constant term
β - The coefficient of X_t or the slope
e_t - The random (stochastic) error term

The estimated trend line equation is given by:

$Y_t = a + bX_t$ ....*(2)*

Where a and b denote the estimators α and β respectively.

$$a = \frac{\sum_{t=1} Y}{n} - \frac{b \sum_{t=1} X}{n} = Y - bX \quad .... (3)$$

$$b = \frac{n \sum_{t=1} XY - \sum_{t=1} X \sum_{t=1} Y}{n \sum_{t=1} X^2 - \{\sum_{t=1} X\}^2} \quad ....(4)$$

Where; n - Numbers of observations
a - Constant term
b - The estimator of the true slope
Y - estimated value of the function Y_t given specified value X_t and also

$\Sigma_t = Y_t - Y_t = Y_t - a - bX_t$............ *(5)*

Table 1: Monthly mean gauge height (m**)**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1998	1.80	1.71	1.66	1.64	1.69	1.99	2.51	4.39	6.16	5.23	2.71	2.39
1999	2.16	2.10	2.05	1.96	2.08	2.13	2.95	3.97	5.54	6.54	3.43	2.44
2000	2.13	1.93	1.86	1.89	2.96	2.78	3.46	5.66	5.36	4.02	2.52	2.21
2001	2.07	2.01	2.01	2.00	2.17	2.43	3.46	4.91	6.02	4.16	2.54	2.10
2002	1.91	1.84	1.89	1.86	1.98	2.35	3.13	3.85	5.65	4.16	2.52	2.00
2003	1.91	1.96	1.95	1.95	1.99	2.60	4.32	5.13	5.90	3.81	2.28	1.99
2004	1.87	1.77	1.81	1.80	1.90	2.19	3.07	4.06	4.98	3.37	2.34	2.02
2005	1.96	1.88	1.89	1.94	2.07	2.45	3.22	4.77	4.76	3.97	2.43	2.04
2006	-	-	-	-	2.1	2.58	3.42	4.57	6.57	5.22	2.51	2.22
2007	2.09	2.09	2.09	2.07	2.27	2.46	3.33	5.60	6.04	3.91	2.36	2.24
2008	2.09	2.03	2.04	2.05	2.09	2.51	3.00	4.86	5.69	5.54	2.49	2.17

Source: UBRBDA

Analysis of data was done to determine the presence of autocorrelation in the set of data used. This analysis was done by testing the hypothesis as shown below:

Hypothesis:
H_0: Ø = 0 (no positive first order autocorrelation of residuals)
H_1: Ø > 0 (there is positive first order autocorrelation of residuals)

Level of Significance (α) = 0.01

Test Statistics

The Durbin – Watson (d) statistics was used to test for the presence of first order autocorrelation. It is given by the formula.

$$d = \frac{\Sigma (e_t - e_{t-1})^2}{\Sigma e^2_t} \quad ....(6)$$

Decision Rule

The value of d always falls in the interval

0 – 4. The value of d are interpreted as follows;
d < 2 for positive autocorrelation of the e's
d > 2 for negative autocorrelation of the e's
d ≈ 2 for zero autocorrelation of the e's
To compare the computed values with the tabulated values, the following steps were taken;

(i) If d < d_1 reject the hypothesis of non autocorrelation in favour of the hypothesis of first order autocorrelation.
(ii) If d > du do not reject the null hypothesis
(iii) If d_1 < d < du, the test is inconclusive.

Data processing
For a better manipulation, data processing was done in a tabular form. The process is presented in table 2 below.

Table 2: Processing of monthly mean gauge data

Monthly mean gauge heights (m)

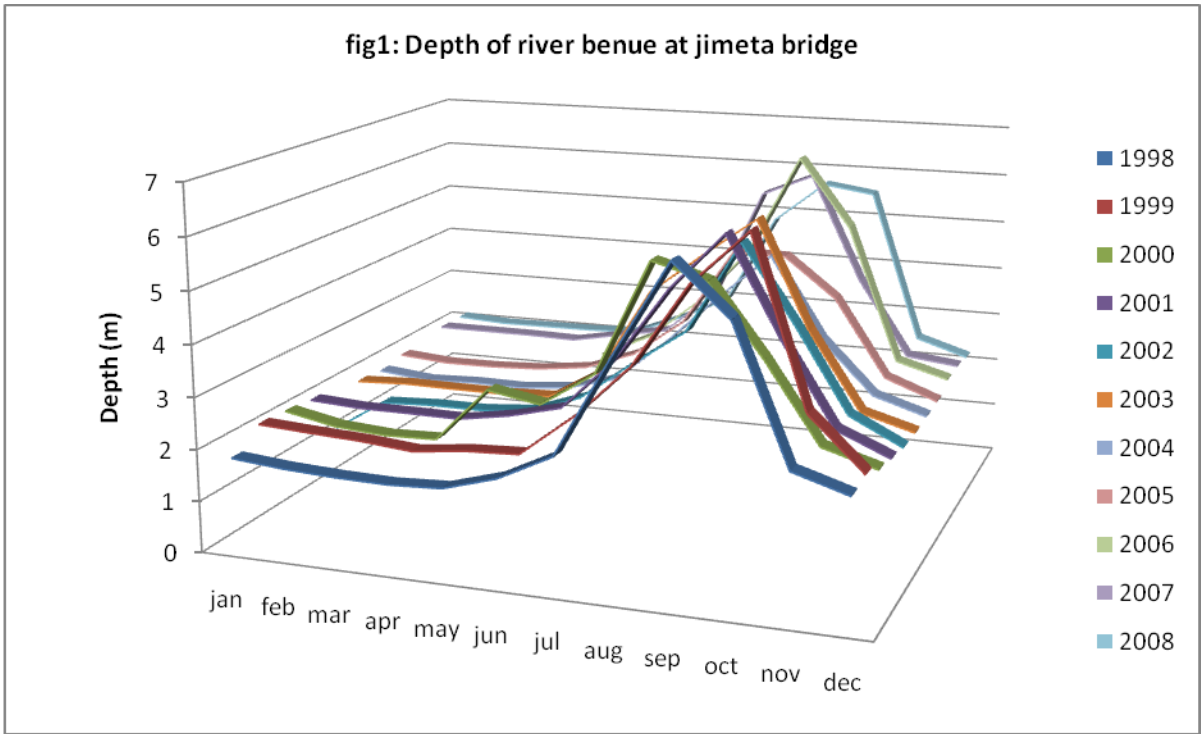
	Months (X)	Observation (Y)	X^2	Y^2	XxY	Y=a+bX	e_t	e_t^2	$(e_t-e_{t-1})^2$
	1	1.8	1	3.24	1.8	2.28646581	-0.48647	0.236649	
	2	1.71	4	2.9241	3.42	4.67293162	-2.86293	8.196377	5.64759
	3	1.64	9	2.6896	4.92	6.859397429	-5.2194	27.24211	5.552931
	4	1.66	16	2.7556	6.64	9.145863239	-7.48586	56.03815	5.136867
	5	1.69	25	2.8561	8.45	11.43232905	-9.74233	94.91298	5.091638
	6	1.99	36	3.9601	11.94	13.71879486	-11.7288	137.5646	3.946046
	‘	‘	'	‘	‘	‘	‘	‘	‘
	‘	‘	‘	‘	‘	‘	‘	‘	‘
	‘	‘	‘	‘	‘	‘	‘	‘	‘
	‘	‘	‘	‘	‘	‘	‘	‘	‘
	127	2.49	15625	6.2001	316.23	290.3811578	-287.891	82881.32	5.227926
	128	2.17	15376	4.7089	277.76	292.6676237	-290.498	84388.87	6.793664
Total	**8256**	**378.36**	**705252**	**1337.0566**	**24797.76**	**18877.06173**	**-18498.7**	**3585462**	**784.4699**

from the processed result on table 2 above, the parameters α (a), β(b) and d were computed and are shown below (table 3):

Table 3: Computed Variables

Variable	Formula	Result
A	α (a) = $a = \frac{n\sum_{t=1} Y}{n} - \frac{b\sum_{t=1} X}{n} = Y - bX$	-15.85306003
B	β(b) = $b = \frac{n\sum_{t=1} XY - \sum_{t=1} X \sum_{t=1} Y}{n\sum_{t=1} X^2 - \{\sum_{t=1} X\}^2}$	0.0022782216

D	$d = \frac{\Sigma (e_t - e_{t-1})^2}{\Sigma e_t^2}$	0.0002187919



Result and Discussion

Hypothesis;

H_0: $\varnothing = 0$ (no positive first order autocorrelation residuals)

H_1: $\varnothing > 0$ (there is positive first order autocorrelation residual)

Level of significance (α) = 0.01

From the Durbin-Watson table, given n = 128 and k = 1 (1st order)

The value of d_1 was obtained as 1.80 and du = 1.84 and the calculated d = 0.0002187919.

$d < d_1$ and d < du based on the hypothesis, the H_0 (null hypothesis) is rejected. Hence, it is concluded that, there is positive first order autocorrelation. The trend from the table shows that, there is a steady increase in the value of the trend at a regular pattern from 2.28646581 to 292.6676237 indicating that there is variation in the depth of water with time. Also from the time series graph, it is noticed that January to June usually have the minimum level of water while July to November usually have the highest level of water.

Conclusion

In this paper an attempt has been made to analyse the depth of river Benue at Jimeta Bridge. The data used was the mean gauge height of river Benue at Jimeta Bridge. The data was processed in order to produce a time series table from where the analysis of the river depth was made.

From the table it was observed that, there is a steady increase in the value of the trend at a regular pattern from 2.28646581 to 292.6676237 indicating that there is variation in the depth of water with time. Also from the time series graph, it is noticed that January to June usually have the minimum level of water while July to

November usually have the highest level of water.

Recommendation

It is hereby, recommended that the data on the depth of river Benue be properly observed and analysed from time to time. This will enable an excellent study on the nature and behaviour of the depth of river Benue at Jimeta Bridge. It is also recommend that there should be further analysis of the depth of the river at other important points for better forecasting of the future. In the case where variation does not obey the trend or the steady rise in trend there is need for caution, because it is likely that there will be over flooding of the river or on the other way round the drying up of the river.

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