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Modelling of Sediment Load for Selected Inflow Rivers of Loktak Lake, Manipur

Taba Lelly[1], Joram Rocky[2], Joram Loker[3], Suman Kamchi[4], Taba Vishnu[5], Thounaojam Clinton Singh[6], Dr. Mimi Das Saikia[7]

[1,2,3,4,5]B. Tech Student
[6]Co-Guide, M. Tech Student
[7]Professor, Dept. of civil Engineering, Assam down town University, Assam, India

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Abstract - *Modelling was done to predict the sediment load of selected inflow rivers of Loktak lake. The selected inflow rivers are Awang Khujairok, Nambol, Nambul and Potsangbam. The variables considered for the modelling are Discharge (in cumec), Stage (in m) and Sediment load (Kg/sec). Data were collected from Loktak Development Authority for the year 1999 and 2000. For analysis simple regression in power form were adopted. The equation from the analysis is proposed to find the sediment load (Kg/sec) for the specific inflow river in a particular period.*

Key Words*: *Regression, Modelling, Discharge, Stage, Sediment Load, Estimated sediment load.

1. INTRODUCTION

Loktak Lake is the largest freshwater lake in Northeast, located in Manipur state in India. It is famous for the Phumdis (heterogenous mass of vegetation, soil and organic at various stages of decomposition) floating over it. It serves as the source of water for hydropower generation, irrigation and drinking water supply. Loktak Lake was designated as wetland of international importance under Ramsar convention in 1990 because of its biological richness where naturally occurring phumdis (floating vegetation) covers the lake extensively. It has a catchment area of 980 sq. km, with surface area of 287 sq. km, average depth of 2.7m and maximum depth of 4.6m. Sediment load in the Loktak Lake has been observed mostly in the areas at the entry of western streams and connected channels, resulting to shrinkage of lake area. As lake is very shallow due to drastic increase in the sediment load it may cause its untimely death. The phumdis of Loktak Lake also play a vital role in retarding the flow and trapping the sediments. From recent survey, it has been observed that the mouth of Ungamel channel, which is said to be very deep in the earlier days are so heavily silted and this day's area is been turned into paddy fields. The study is done on selected inflow rivers, i.e. Awang Khujairok, Nambol, Nambul and Potsangbam. For analysis purpose simple regression method in power form was adopted.

2. METHODS AND ANALYSIS

2.1 METHODS

Regression modelling is a basic and commonly used time of predictive analysis. In this study simple regression modelling was done to propose a mathematical equation to estimate the sediment load (kg/sec) for selected inflow rivers. And the selected inflow rivers are Awang Khujairok, Nambul, Nambol, and Potsangbam. The regression was performed in Microsoft office and Microsoft Excel. The regression was done on two variables i.e. stage (in m) and discharge (in cumec) in power form or equation. Following equation depicts the proposed equation.

$$Y=ax^b$$

Where,
Y = sediment load (in kg/sec)
a, b = regression co-efficient
x = variables i.e stage and discharge

The variables were plotted in scattered graph. Independent variables (i.e. stage and discharge) were plotted in x-axis and dependent variable (i.e. sediment load)were plotted in y-axis.

2.2 ANALYSIS

Regression was done in Microsoft office and Microsoft excel. the independent variable (stage and discharge) was plotted in x-axis and the dependent variable (sediment load) was plotted in y-axis. Following graph shows the plotting of variables.

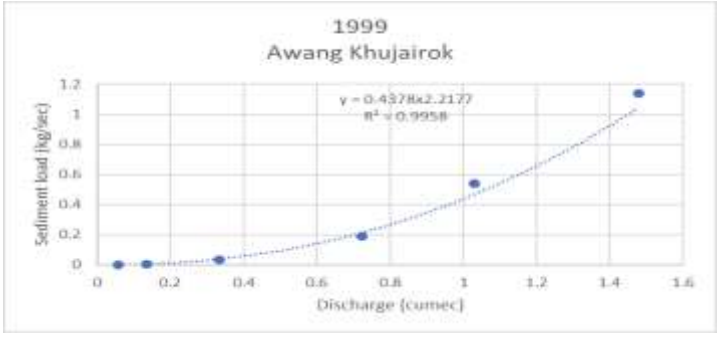

Figure 1 Discharge-sediment load for the year 1999

Figure 1 shows the graph plotted between discharge (in cumec) and sediment load (kg/sec) from January to December 1999. Statistical regression has been done for the given data set. And it has been observed that the relationship between sediment load (kg/sec) and discharge (in cumec) gives the best fit curve in power equation. The equation here, has been proposed as $y = 0.4378x^{2.2177}$ and $R^2 = 0.9958$. where y = sediment load (in kg/sec) and x = discharge (in cumec).

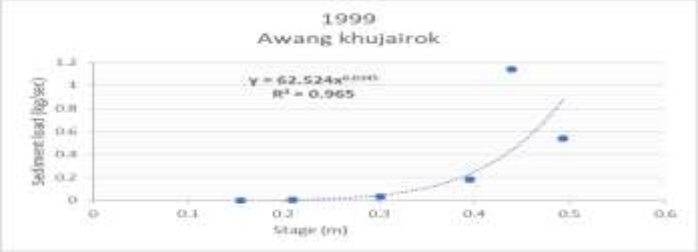

Figure 2 stage-sediment load for the year 2000

Figure 2 shows the graph plotted between stage (in meter) and sediment load (kg/sec) from January to December 1999. Statistical regression has been done for the given data set. And it has been observed that the relationship between sediment load (kg/sec) and stage (in meter) gives the best fit curve in power equation. The equation here, has been proposed as $y = 62.524x^{6.0345}$and $R^2 = 0.965$. Where y = sediment load (in kg/sec) and x = stage (in meter).

Same procedures were adopted for rest of the selected inflows rivers for the year 1999 and 2000. Following table depicts the proposed equations which were obtained after regression analysis for stage-sediment load and discharge-sediment load for the year 1999 and 2000.

Table 1 Proposed Equation.

Sl. No.	Year	Inflow river	Regression equation (Proposed equation)	R^2
Discharge-Sediment Load				
1	1999	Awang Khujairok	$y = 0.4378x^{2.2177}$	0.9958
2	1999	Nambol	$y = 0.1476x^{1.6034}$	0.9931
3	1999	Nambul	$y = 0.0895x^{1.4478}$	0.9981
4	1999	Potsangbam	$y = 0.4287x^{2.7457}$	0.9514
5	2000	Awang Khujairok	$y = 0.4541x^{2.4361}$	0.9514
6	2000	Nambol	$y = 0.142x^{1.6075}$	0.9954
7	2000	Nambul	$y = 0.0923x^{1.4088}$	0.992
8	2000	Potsangbam	$y = 0.3454x^{2.652}$	0.9663
Stage-Sediment Load				
9	1999	Awang Khujairok	$y = 62.524x^{6.0345}$	0.965
10	1999	Nambol	$y = 0.0323x^{5.3303}$	0.8311
11	1999	Nambul	$y = 0.9661x^{1.1249}$	0.8239
12	1999	Potsangbam	$y = 0.7865x^{2.7953}$	0.8685
13	2000	Awang Khujairok	$y = 16.852x^{4.8609}$	0.656
14	2000	Nambol	$y = 0.0826x^{4.1682}$	0.6433
15	2000	Nambul	$y = 0.4383x^{2.9519}$	0.8958
16	2000	Potsangbam	$y = 2.7566x^{4.3739}$	0.797

2.2.1 VALIDATION OF THE PROPOSED MATHEMATICAL MODEL

For validation of the equations the Estimated sediment loads are compared with the observed sediment loads. The comparisons are presented and plotted in the following tables and graphs respectively. Graphs are plotted for the Discharge-sediment load, Stage-sediment load and actual sediment load for the year 1999 and 2000.

Table 2 Observed sediment loads and Estimated sediment loads for the year 1999.

Year:- 1999 Observed Sediment load, Estimated stage-sediment load, Estimated discharge-Sediment load (Kg/sec)							
Month	Awang Khujairok			Month	Nambol		
	Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-Sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment load (kg/sec)		Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment load (kg/sec)
Jan				Jan	0.001	0.004299164	0.001133936
Feb				Feb			
Mar				Mar			
April				April			
May				May	0.886	0.055529349	0.487955804
June				June	3.507	1.668454828	3.189527198
July	1.139	0.435009661	1.042831586	July	3.614	7.122960671	4.328432036
Aug	0.538	0.876055234	0.468467535	Aug	5.941	8.158808057	7.023215662
Sept	0.188	0.229991575	0.21324888	Sept	4.623	8.712664629	5.629710149
Oct	0.035	0.04461247	0.038466998	Oct	3.052	1.781777289	2.74604784
Nov	0.004	0.004937073	0.005075234	Nov	0.121	0.140730307	0.13434404
Dec	0.001	0.000813024	0.000792374	Dec	0.022	0.049649983	0.02245359
Month	Nambul			Month	Potsangbam		
	Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment load (kg/sec)		Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment load (kg/sec)
Jan	0.034	0.862414301	0.03589202	Jan			
Feb	0.016	0.962840314	0.017038722	Feb			
Mar	0.016	1.241755682	0.017271936	Mar			
April				April			
May	4.769	2.246081317	4.309874635	May	0.167	0.462489501	0.195298118
June	1.48	1.144966297	1.173435225	June	2.748	3.210487806	4.175171996
July	3.597	2.350178235	3.933337217	July	2.301	2.79502723	2.95499492
Aug	3.661	2.386193941	3.882500798	Aug	0.84	0.79754192	0.33189682
Sept	2.127	2.243694479	2.502806263	Sept	0.907	0.52099038	0.849789604
Oct	1.567	1.677298047	1.546331497	Oct	0.591	0.179102649	0.439377141
Nov	0.037	0.399384893	0.032429586	Nov	0.057	0.038551541	0.063566478
Dec	0.008	0.004228711	0.007777397	Dec	0.008	0.018212675	0.011416302

Table 3 Observed sediment loads and Estimated sediment loads for the year 2000.

Year:- 2000 Observed Sediment load, Estimated stage-sediment load, Estimated discharge-Sediment load (Kg/sec)							
Month	Awang Khujairok			Month	Nambol		
	Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-Sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment (kg/sec)		Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment (kg/sec)
Jan		0.000352921	2.91087E-05	Jan	0.009	0.08681074	0.010088387
Feb				Feb			
Mar	0.01	0.03007097	0.011865627	Mar	0.053	0.016858247	0.04555539
April	0.253	0.574312664	0.486851594	April	1.909	0.08788845	1.233261465
May	0.328	0.137753812	0.241755302	May	4.505	3.286996607	4.711479706
June	0.079	0.067270052	0.0656197	June	2.873	2.277109444	2.927687213
July	0.294	0.343760276	0.319844464	July	3.982	2.976127493	4.06975536
Aug	0.331	0.101011674	0.240232388	Aug	1.274	1.013855209	1.437070616
Sept	0.188	0.351267688	0.206062188	Sept	6.504	6.750001418	7.822169943
Oct	0.29	0.115880419	0.222397837	Oct	5.028	3.783071597	4.925057961
Nov	0.012	0.01845219	0.01292459	Nov	0.103	0.359392253	0.105654158
Dec		0.002144883	0.000138089	Dec	0.017	0.128574256	0.01834826
Month	Nambul			Month	Potsangbam		
	Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment (kg/sec)		Observed Sediment load (Kg/sec)	Estimated Sediment load for stage-sediment load (Kg/sec)	Estimated Sediment load for Discharge-sediment (kg/sec)
Jan	0.012	0.028246617	0.013761267	Jan			
Feb	0.016	0.029532033	0.017565962	Feb	0.006	0.005076747	0.006927971
Mar	0.065	0.071481964	0.066691245	Mar	0.109	0.136477784	0.118005988
April	0.163	0.022553362	0.09022631	April	1.779	1.816085624	1.852835555
May	2.35	1.374957135	2.15511151	May	2.036	0.977684784	0.935462321
June	2.53	2.829695839	2.701420627	June	0.883	1.067417584	0.945720418
July	1.513	1.729367128	1.687398395	July	0.042	0.153889872	0.037983575
Aug	1.62	1.601173658	1.778445289	Aug	1.021	0.924633104	0.762535255
Sept	5.024	6.537693809	5.597243388	Sept	1.293	1.432465054	1.695495406
Oct	4.096	2.78112628	3.609396585	Oct	1.123	0.436043136	1.223318959
Nov	0.094	0.133797139	0.099265604	Nov	0.384	0.095886341	0.719799484
Dec	0.032	0.052089846	0.036042511	Dec	0.054	0.241304962	0.04663649

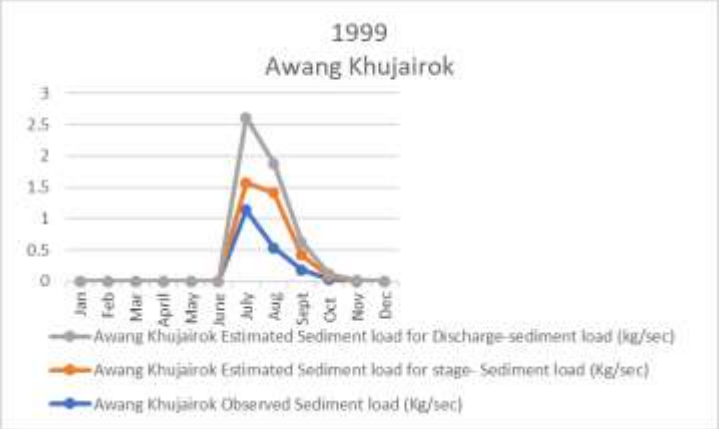

Figure 3 Observed sediment loads and Estimated sediment loads for the year 1999

Graph represents observed and estimated sediments loads from the proposed equation. The trend followed by the estimated sediment load by both the prediction equation, i.e. sediment load vs stage and sediment load vs discharge follow the same pattern with the observed one. The values of sediment load by the proposed equation are estimated to be little higher than the observed sediment load. The predictions in the equation give the value to higher side. A comparison of estimated values with respect to the observe values has been presented graphically in figure 3.

2.2.2 RESULTS

The data collected for the inflow rivers to the Loktak lake for the year 1999 and 2000 simple regressions analysis has been adopted to find a relationship between the sediment load vs stage and sediment load vs discharge. These relationships will be helpful for prediction of sediment load when the known variables are discharge and stage. With the help of the proposed equation, sediment loads for the stage and discharge has been estimated. When the estimated sediment load for both (i.e. stage and discharge) are plotted. It has been observed that the value of estimated sediment loads are higher than the observed sediment load, little high but it maintains the same trend for the peak of the graph has been presented here. The detailed data has been analysed. And required mathematical modelling has been done and proposed.

3. CONCLUSION

In this project an effort has been made to propose a mathematical modelling to predict the sediment load of the Inflow Rivers of Loktak lake in relation to Discharge and stage for the rivers Awang Khujairok, Nambol, Nambul, and Potsangbam. The data were collected from Loktak Development Authority for the year 1999 and 2000. For analysis purpose simple regression in power equation has been adopted, as the power equation gives the closest value of R2 to 1. The proposed equation has been validated by comparing the observed sediment load to estimated

sediment load of the all the inflow rivers for the year 1999 and 2000. It has been observed that the calculated sediment load is higher than the actual sediment load. Nevertheless, the pattern in graph follows the same pattern. Hence the proposed mathematical modelling can be used to predict the sediment load when value of Discharge and stage are provided.

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