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Original Article

Tidal Analysis for Wave Runoff Mitigation on Coastal Area of Bulo

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Abstract *- Indonesian coast has its big potential to be used as a center of human activity. The growing utilization of coastal areas is accompanied by the increase of coastal issues, such as the reverse of coastline caused by erosion, where erosion itself is due to wave and thus has its consequences to the settlement and tourism region along the coast. Some human activities in a coastal area, such as harbor, navigation, tourism, and some other things, must be managed purposefully to keep to coastal profile uninterrupted. Bulo coast, located in the Rerer village Minahasa regency, is potential beach tourism. Currently, the Bulo coast has degradation in its coastal profile as a process of wave runoff. Periodically tidal are the factor affecting the coastal area; therefore, the analysis must be carried out rigorously to obtain the correct sea level prior to overseeing activity in the coastal area. Facing the fact that every coastal area has its own tidal condition, this research aims to determine the tidal type and water level at the Bulo coast by using the Admiralty method. The tidal data is collected from direct measurement in the location for 15 days in a row. The analysis gives a result that the Bulo coast has a mixed tide prevailing semidiurnal type with the highest high water level (HHWL) of 145 cm (+70.4 cm from MSL), and the lowest low water level (LLWL) is 3 cm (-71.6 cm from MSL).*

Keywords — *Bulo coast, tidal analysis, Admiralty method*

I. INTRODUCTION

Sea wave is a predominant parameter to the rate of the reverse of the coastline. It happens because of the windblown on the sea surface, the differences in sea temperatures, the differences in salt content, and the eruption of a volcano on/underneath the sea. The reverse of the coast line from its initial position is caused by wave, current, and the unbalanced between inflow sediment and outflow sediment. The coastal area of Bulo, located in Rerer village of Kombi district, is one of the tourism places in the Minahasa regency. A high wave occurs at certain months on the Bulo coast, resulting from the loss of income of the local resident as the condition is getting worse when high tides, the knowledge of the type of tidal is a necessity.

The phenomenon of up and down of seawater periodically is caused by the pull force of astronomical objects, mainly such as sun, earth, and moon. The effect of astronomical objects other than the main three is neglected since they have smaller sizes and are long-distance. Sun has a mass of twenty-seven million times larger than the moon's but its distance is far from earth (149.6 million km) compared to the moon, which is only 381.16 km from earth. In the theory of the multiverse, distance dictates rather than mass. Therefore, the moon plays a role in defining the tidal since its pull force is 2.25 times larger than the sun. In civil engineering, designing construction in the coastal area requires tidal information. This is the purpose of research, where obtaining tidal type in Bulo coast will provide good information to the design process. The analysis will use the Admiralty method. The Admiralty method can analyze short data of tidal acquired in 15 days in a row and provide some constants to be used in further analysis, especially to determine the type of tidal as well as the elevation of sea level.

II. AREA OF RESEARCH

The research is located on the Bulo coast at Rerer village of Kombi district, in Minahasa regency, Indonesia. The geographical position is 1°16' 12.4674" of North Latitude and 125°3' 34.6674" of East Longitude. The aim of the research is to obtain the type of tidal in the Bulo coast and the sea level at the highest high water level (HHWL) and at the lowest low water level (LLWL).

III. RESEARCH METHODOLOGY

The research will be carried out with the following procedure:

A. Primary Data Collection

Primary data is collected by direct measurement of high and low tides on the Bulo coast. The first step is setting up an observation point on an erected post. The coordinates of the post are 1º15' of North Latitude and 125º3' of East

Longitude. By using water pass, the details of the observation point are:

- The designated angle between water pass (0^o as initial position) and North direction = 111^o
- Upper horizontal axis = 355 cm
- Middle horizontal = 335 cm
- Lower horizontal axis = 315 cm
- Height of water pass (measure from the ground) = 41 cm
- The horizontal distance between the erected post and ruler = 46 m

Based on the details of the observation point, the high and low tides are measured for 15 days in a row.

B. Data Analysis

In the data analysis, the Admiralty method is used to produce the components of tidal. The type of tidal is then determined using the Formzahl number (F).

IV. RESULT AND DISCUSSION

The result of high and low tides measurement during 15 days in a row is shown in Table I. Table II contains the multiplier constants for arranging the second scheme of the Admiralty method. The solution of the second scheme is through columns 6 to 8 of Table III. The formulation is written in Table III. Repeat the calculation in Table III for another day of observation until all day of observation is fulfilled. Column 4 of Table IV contains the result of X1 from all days of observation (summation of column 6 of Table III of each date of observation). For control, the summation of column 5 and column 6 for X1 will give the same number as in other columns of X and Y, except for X4.

TABLE I
Observation Result of Tidal at Bulo Coast: March 17, 2021 – March 31, 2021

NO	Tanggal	Bacaan Skala Pada Jam											
		00:00	01.00	02:00	03:00	04.00	05:00	06:00	07:00	08:00	09:00	10:00	11:00
1	03/17/21	100	120	125	135	140	130	120	75	40	12	3	3
2	03/18/21	95	110	130	140	140	145	145	145	130	120	80	45
3	03/19/21	90	90	110	120	135	140	145	145	135	120	75	50
4	03/20/21	80	82	88	93	96	100	125	140	145	135	105	65
5	03/21/21	95	97	100	100	105	110	110	110	120	120	105	75
6	03/22/21	100	80	75	70	68	65	60	70	90	105	100	90
7	03/23/21	115	117	120	122	125	125	100	80	80	85	85	85
8	03/24/21	75	80	80	75	75	72	75	80	80	85	90	90
9	03/25/21	75	85	95	80	80	70	65	55	45	50	55	65
10	03/26/21	95	85	85	87	73	62	60	55	45	30	35	40
11	03/27/21	90	90	80	75	60	56	33	35	28	30	30	35
12	03/28/21	100	96	97	82	73	68	52	46	40	35	15	5
13	03/29/21	136	140	142	140	120	100	82	73	64	36	15	5
14	03/30/21	130	135	138	140	142	140	140	130	100	68	35	20
15	03/31/21	120	136	140	140	142	145	145	140	130	100	76	43

NO	Tanggal	Bacaan Skala Pada Jam												m. Baca	Rata2/jam
		12:00	13.00	14:00	15:00	16.00	17:00	18:00	19:00	20:00	21:00	22:00	23:00		
1	03/17/21	5	5	10	20	50	65	75	80	80	85	95	96	1003	41,79
2	03/18/21	20	5	5	10	30	50	65	75	85	90	95	97	1425	59,38
3	03/19/21	25	5	10	15	25	40	50	60	75	80	85	85	1355	56,46
4	03/20/21	50	25	15	10	20	30	35	45	66	70	70	80	1254	52,25
5	03/21/21	65	45	25	20	25	25	45	45	56	80	90	94	1247	51,96
6	03/22/21	80	71	53	45	30	28	8	40	55	90	100	110	973	40,54
7	03/23/21	85	80	75	60	40	35	20	20	26	46	57	78	1239	51,63
8	03/24/21	80	82	70	60	45	40	40	40	52	60	60	65	957	39,88
9	03/25/21	70	75	75	70	65	60	40	35	50	50	65	70	820	34,17
10	03/26/21	40	65	70	70	70	68	73	75	80	80	85	88	752	31,33
11	03/27/21	35	45	60	70	80	82	80	83	85	85	90	93	642	26,75
12	03/28/21	5	25	40	50	68	85	86	90	95	95	98	100	709	29,54
13	03/29/21	5	15	30	40	50	80	90	96	100	100	110	115	1053	43,88
14	03/30/21	5	5	15	30	50	80	80	90	100	130	120	122	1318	54,92
15	03/31/21	15	5	30	30	45	65	65	70	83	90	96	110	1457	60,71

TABLE II
Multiplier Constants for arranging of the Second Scheme of Admiralty Method

	Jam Pengamatan										
	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00
X1	-1	-1	-1	-1	-1	-1	1	1	1	1	1
Y1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
X2	1	1	1	-1	-1	-1	-1	-1	-1	1	1
Y2	1	1	1	1	1	1	-1	1	-1	-1	-1
X4	1	0	-1	-1	0	1	1	0	-1	-1	0
Y4	1	1	1	-1	-1	-1	1	1	1	-1	-1

	Jam Pengamatan												
	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
X1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1
Y1	-1	1	1	1	1	1	1	1	1	1	1	1	1
X2	1	1	1	1	-1	-1	-1	-1	-1	-1	1	1	1
Y2	-1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1
X4	1	1	0	-1	-1	0	1	1	0	-1	-1	0	1
Y4	-1	1	1	1	-1	-1	-1	1	1	1	-1	-1	-1

TABLE III
Definition of X1 based on measurement at March 17, 2021

1.Tabel Penentuan X1 tanggal 17 Maret 2021

Jam	Data Pengamatan	Konstanta pengali dari tabel 2			Hasil Perkalian		
	dari tbl. 1. no. 1	0	+	-	+	0	-
1	2	3	4	5	6=2*4	7=2*3	8=2*5
0:00	100.00			-1			-100
1:00	120.00			-1			-120
2:00	125.00			-1			-125
3:00	135.00			-1			-135
4:00	140.00			-1			-140
5:00	130.00			-1			-130
0:00	120.00		1		120		
7:00	75.00		1		75		
8:00	40.00		1		40		
9:00	12.00		1		12		
10:00	3.00		1		3		
11:00	3.00		1		3		
12:00	5.00		1		5		
13:00	5.00		1		5		
14:00	10.00		1		10		
15:00	20.00		1		20		
16:00	50.00		1		50		
17:00	65.00		1		65		
18:00	75.00			-1			-75
19:00	80.00			-1			-80
20:00	80.00			-1			-80
21:00	85.00			-1			-85
22:00	95.00			-1			-95
23:00	95.00			-1			-95
Jumlah	1668				408		-1260

TABLE IV
Arrangement of X1, Y1, X2, Y2, X4, and Y4 based on the Second Scheme of Admiralty Method

Waktu			X1		Y1		X2		Y2		X4		Y4	
Tgl	Bln	Thn	+	-	+	-	+	-	+	-	+	-	+	-
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
17	3	2021	408.0	1260.0	665.0	1003.0	658.0	1010.0	905.0	763.0	593.0	507.0	835.0	833.0
18	3	2021	785.0	1267.0	627.0	1425.0	892.0	1160.0	880.0	1172.0	662.0	710.0	1010.0	1042.0
19	3	2021	790.0	1120.0	555.0	1355.0	825.0	1085.0	805.0	1105.0	625.0	665.0	940.0	970.0
20	3	2021	865.0	905.0	516.0	1254.0	865.0	905.0	689.0	1081.0	565.0	622.0	896.0	874.0
21	3	2021	845.0	1017.0	615.0	1247.0	991.0	871.0	812.0	1050.0	619.0	621.0	913.0	949.0
22	3	2021	822.0	861.0	710.0	973.0	1054.0	629.0	765.0	918.0	541.0	583.0	782.0	901.0
23	3	2021	890.0	971.0	622.0	1239.0	1028.0	833.0	1099.0	762.0	643.0	614.0	918.0	943.0
24	3	2021	877.0	774.0	694.0	957.0	917.0	734.0	834.0	817.0	537.0	562.0	834.0	817.0
25	3	2021	750.0	795.0	725.0	820.0	830.0	715.0	900.0	645.0	515.0	515.0	765.0	780.0
26	3	2021	648.0	968.0	864.0	752.0	798.0	818.0	870.0	746.0	526.0	547.0	828.0	788.0
27	3	2021	563.0	967.0	888.0	642.0	763.0	767.0	823.0	707.0	504.0	513.0	744.0	786.0
28	3	2021	466.0	1080.0	837.0	709.0	711.0	835.0	789.0	757.0	501.0	534.0	772.0	774.0
29	3	2021	495.0	1389.0	831.0	1053.0	849.0	1035.0	998.0	886.0	613.0	652.0	973.0	911.0
30	3	2021	678.0	1467.0	827.0	1318.0	923.0	1222.0	1010.0	1135.0	717.0	721.0	1068.0	1077.0
31	3	2021	804.0	1337.0	684.0	1457.0	941.0	1200.0	993.0	1148.0	708.0	723.0	1059.0	1082.0

TABLE V
Arrangement of X and Y – The First Index of Third Scheme

Waktu			X0	X1	Y1	X2	Y2	X4	Y4
Tgl	Bln	Thn		1000	1000	1000	1000	1000	1000
1	2	3	4	5	6	7	8	9	10
17	3	2021	1668.00	148.00	662.00	648.00	1142.00	1086.00	1002.00
18	3	2021	2052.00	518.00	202.00	732.00	708.00	952.00	68.00
19	3	2021	1910.00	670.00	200.00	740.00	700.00	960.00	70.00
20	3	2021	1770.00	960.00	262.00	960.00	608.00	943.00	122.00
21	3	2021	1862.00	828.00	368.00	1120.00	762.00	998.00	64.00
22	3	2021	1683.00	961.00	737.00	1425.00	847.00	958.00	-19.00
23	3	2021	1861.00	919.00	383.00	1195.00	1337.00	1029.00	75.00
24	3	2021	1651.00	1103.00	737.00	1183.00	1017.00	975.00	117.00
25	3	2021	1545.00	955.00	905.00	1115.00	1255.00	1000.00	85.00
26	3	2021	1616.00	680.00	1112.00	980.00	1124.00	979.00	140.00
27	3	2021	1530.00	596.00	1246.00	996.00	1116.00	991.00	58.00
28	3	2021	1546.00	386.00	1128.00	876.00	1032.00	967.00	98.00
29	3	2021	1884.00	106.00	778.00	814.00	1112.00	961.00	162.00
30	3	2021	2145.00	211.00	509.00	701.00	875.00	996.00	91.00
31	3	2021	2141.00	467.00	227.00	741.00	845.00	985.00	77.00
Jumlah			26864.00	9508.00	9456.00	14226.00	14480.00	14780.00	2210.00

In Table V, column 4 (X0) is equal Σ X1 (column 4 + column 5, of Table IV). The calculation of column 5 of Table V is column 4 of Table IV – column 5 of Table IV. Whenever the result is negative, add B (=1000) to the result. For example: 408 (column 4, Table IV) – 1260 (column 5, Table IV) = -852. Thus for column 5 of Table V: -852 + B (=1000) = 148 (column 5 of Table V). Repeat the calculation for all days of observation.

Column 7 of Table VII is as same as column 4 of Table V. In Table VIII, the calculation of X00 or the second index must be a positive number since it has positive multiplier constants. The daily result is summed and inserted into columns 3 and 4 of Table VIII. In Table X, the results in column 3 to column 10 are obtained by multiplying the number in column 2 with the corresponding multiplier constant in Table IX. In Table X, the results in column 3 to column 10 are obtained by multiplying the number in column 2 with the corresponding multiplier constant in Table IX.

TABLE VI
Multiplier Constants for calculating X00, X10 and Y10

Indeks Kedua		0	2	b	3	c	4	d
Pengali untuk B (15 plantan)		-15	1	0	5	0	1	0
Waktu Menengah	Konstanta Untuk 15 Plantan	1	-1	0	-1	-1	1	0
		1	-1	1	-1	-1	1	-1
		1	-1	1	-1	-1	-1	-1
		1	-1	1	-1	1	-1	-1
		1	1	1	-1	1	-1	1
		1	1	1	1	1	-1	1
		1	1	1	1	1	1	1
		1	1	0	1	0	1	0
		1	1	-1	1	-1	1	-1
		1	1	-1	1	-1	-1	-1
		1	1	-1	-1	-1	-1	-1
		1	-1	-1	-1	-1	-1	1
		1	-1	-1	-1	1	-1	1
		1	-1	-1	-1	1	1	1
		1	-1	0	-1	1	1	0

TABLE VII
Calculation of X00

Tabel Perhitungan harga X00

Waktu Pengamatan			Konstanta			X0	X00	
Tgl	Bln	Thn	0	1	-1		+	-
1	2	3	4	5	6	7	8=5*7	9=6*7
17	3	2021		1		1668.00	1668	
18	3	2021		1		2052.00	2052	
19	3	2021		1		1910.00	1910	
20	3	2021		1		1770.00	1770	
21	3	2021		1		1862.00	1862	
22	3	2021		1		1683.00	1683	
23	3	2021		1		1861.00	1861	
24	3	2021		1		1651.00	1651	
25	3	2021		1		1545.00	1545	
26	3	2021		1		1616.00	1616	
27	3	2021		1		1530.00	1530	
28	3	2021		1		1546.00	1546	
29	3	2021		1		1884.00	1884	
30	3	2021		1		2145.00	2145	
31	3	2021		1		2141.00	2141	
Jumlah						26864.00	26864	0

TABLE VIII
Arrangement of X and Y – The Second Index of Fourth Scheme

Indeks Tanda		Besarnya Harga		$\bar{X}$	$\bar{Y}$
		X	Y		
1	2	3	4	5=(3⁺)-(3⁻)	6=(4⁺)-(4⁻)
00	+	26864		26864	
10	+	9508	9456		
	-	15000	15000	-5492	-5544
12	+	6042	5488		
	-	3466	3968		
	+	1000	1000	3576	2520
1b	+	4856	2152		
	-	2934	5678	1922	-3526
13	+	4618	3874		
	-	4890	5582		
	+	1000	1000	728	-708
1c	+	4452	3264		
	-	3953	5455	499	-2191
20	+	14226	14480		
	-	15000	15000	-774	-520
22	+	8014	7458		
	-	6212	7022		
	+	1000	1000	2802	1436
2b	+	6172	4962		
	-	5482	6514	690	-1552
23	+	5898	5580		
	-	8328	8900		
	+	1000	1000	-1430	-2320
2c	+	6956	6386		
	-	6087	7077	869	-691
42	+	6930	520		
	-	7850	1690		
	+	1000	1000	80	-170
4b	+	5840	380		
	-	5894	634	-54	-254
44	+	7023	1515		
	-	7757	733		
	+	1000	1000	266	1782
4d	+	5909	471		
	-	5825	543	84	-72

TABLE IX
Multiplier Numbers for 15 Diurnals

		S0	M2	S2	N2	K1	O1	M4	MS4
1	2	3	4	5	6	7	8	9	10
untuk skema 5 harga P.R.Cos r	X00	1.00							
	X10	0.01	0.01	0.01	0.03	1.00	0.07	0.01	
	X12 Y1b	-0.02	0.09	0.01	-0.09	0.09	1.00	-0.02	0.02
	X13 Y1c	0.04	0.07	0.01	0.13	0.20	0.59	0.03	
	X20	-0.01	0.15	1.00	0.29	0.01		0.02	
	X22 Y2b	0.01	1.00	0.14	-0.61	0.02	0.03	0.03	-0.01
	X23 Y2c	-0.02	0.65	0.25	1.00	0.03		-0.05	-0.01
	X42 Y4b		0.01		0.01			0.20	1.00
	X44 Y4d		0.01	0.01	0.02			1.01	-0.05
untuk skema 6 harga P.R.Sin r	Y10			0.01	0.02	1.01	0.08	0.01	0.01
	Y12+X1b		0.05	0.01	-0.05	0.12	1.05	-0.03	0.01
	Y13+X1c		0.02	0.02	0.09	0.24	0.65	0.04	0.02
	Y20		0.16	1.00	0.30	0.01	0.02	-0.03	-0.01
	Y22+X2b		1.04	0.15	-0.64	0.02	0.10	0.04	-0.02
	Y23+X2c		0.70	0.26	1.03	0.03	0.09	-0.07	-0.03
	Y42+X4b		0.02					0.11	1.00
	Y44+X4d		0.03	0.01	0.05			1.00	-0.06
Skema 7		360	175	214	166	217	177	273	280
Skema 7			333	345	327	173	160	307	318

TABLE X
Arrangement of X and Y from Tidal Constants of 15 Diurnals

			SO	M2	S2	N2	K1	O1	M4	MS4
1	2		3	4	5	6	7	8	9	10
untuk skema 5 harga P.R.Cos r	X00	= 26864	26864.00							
	X10	= -5492	-54.92	54.92	-54.92	-164.76	-5492.00	-384.44	-54.92	
	X12-Y1b	= 7102	-142.04	639.18	-71.02	-639.18	639.18	7102.00	-142.04	142.04
	X13-Y1c	= 2919	116.76	-204.33	29.19	379.47	583.80	-1722.21	87.57	
	X20	= -774	7.74	116.10	-774.00	-224.46	-7.74	0.00	-15.48	
	X22-Y2b	= 4354	43.54	4354.00	-609.56	-2655.94	-87.08	-130.62	130.62	-43.54
	X23-Y2c	= -739	14.78	480.35	-184.75	-739.00	-22.17		36.95	7.39
	X42-Y4b	= 334		3.34		3.34			66.80	334.00
	X44-Y4d	= 338		-3.38	3.38	6.76			341.38	-16.90
untuk skema 6 harga P.R.Sin r	Y10	= -5544			55.44	-110.88	-5599.44	443.52	-55.44	-55.44
	Y12+X1b	= 4442		222.10	44.42	-222.10	533.04	4664.10	-133.26	44.42
	Y13+X1c	= -209		4.18	4.18	-18.81	-50.16	135.85	-8.36	-4.18
	Y20	= -520		83.20	-520.00	-156.00	5.20	-10.40	15.60	5.20
	Y22+X2b	= 2126		2211.04	-318.90	-1360.64	42.52	212.60	85.04	-42.52
	Y23+X2c	= -1451		1015.70	-377.26	-1494.53	43.53	-130.59	101.57	43.53
	Y42+X4b	= -224		-4.48					-24.64	-224.00
	Y44+X4d	= 1866		-55.98	18.66	93.30			1866.00	-111.96
	Skema 5 (P.R. Cos r)		26849.86	5440.18	-1661.68	-4033.77	-4386.01	4864.73	450.88	422.99
	Skema 6 (P.R. Sin r)			3475.76	-1093.46	-3269.66	-5025.31	5315.08	1846.51	-344.95

TABLE XI
Calculation of w and (1+W) from Tidal Constants

w dan (1+w) untuk S2 dan MS4			
VII : K1 : V		=	90.41
VII : K1 : u		=	4.66
V+u		=	95.07
Tabel 10 : S2 : w/f		=	-0.47
Tabel 10 : S2 : W/f		=	0.27
Tabel 5 : K2 : f		=	1.25
	w	=	-0.59
	W	=	0.34
	1+w	=	1.34
w dan (1+W) untuk K1			
VII : K1 : 2V		=	180.82
VII : K1 : u		=	4.66
2V+u		=	185.48
Tabel 10 : K1 : wf		=	2.69
Tabel 10 : K1 : Wf		=	-0.33
Tabel 5 : K1 : f		=	1.09
	w	=	2.45
	W	=	-0.30
	1+w	=	0.70
w dan (1+W) untuk N2			
VII : M2 : 3V		=	586.23
VII : N2 : 2V		=	1329.60
M2-N2+(360*3)		=	336.63
	w	=	-3.61
	1+W	=	1.17

TABLE XII
The Result of Seventh Scheme for Tidal Constants

	S0	M2	S2	N2	K1	O1	M4	MS4	K2	P1
PR Cos r	26849.86	5440.18	-1661.68	-4033.77	-4386.01	4864.73	450.88	422.99		
PR Sin r		3475.76	-1093.46	-3269.66	-5025.31	5315.08	1846.51	-344.95		
PR	26849.86	6455.73	1989.18	5192.49	6670.14	7205.25	1900.76	545.81		
P	360.00	175.00	214.00	166.00	277.00	177.00	273.00	280.00		
f	0.00	0.97	1.00	0.97	1.09	1.15	0.94	0.97	1.25	
V'	0.00	34.71	0.00	135.40	9.51	277.20	0.00	0.00		
V''	0.00	1.50	0.00	310.70	58.20	303.30	0.00	0.00		
V'''	0.00	159.20	0.00	218.70	22.70	136.60	0.00	0.00		
V	0.00	195.41	0.00	664.80	90.41	717.10	390.82	195.41		
u	0.00	1.28	0.00	1.28	4.66	-5.28	2.56	1.28		
p	0.00	333.00	345.00	327.00	173.00	160.00	307.00	318.00		
r	0.00	212.57	213.35	399.03	228.89	407.53	256.28	140.80		
w	0.00	0.00	-0.59	-3.61	2.45	0.00	0.00	-0.59		
1+W	0.00	1.00	1.34	1.17	0.70	1.00	1.00	1.34		
g	0.00	742.26	557.76	1388.50	499.41	1279.35	956.66	654.90		
Kelipatan 360	0.00	720.00	360.00	1080.00	360.00	1080.00	720.00	360.00		
A cm	74.58	37.98	6.95	27.52	31.37	35.30	7.38	1.50	1.88	10.35
g°		22.26	197.76	308.50	139.41	199.35	236.66	294.90	197.76	139.41

TABLE XIII
The Eighth Scheme of Admiralty Method

	SO	M2	S2	N2	K1	O1	M4	MS4	K2	P1
A (CM)	74.58	37.98	6.95	27.52	31.37	35.30	7.38	1.50	1.88	10.35
g (o)	0.00	22.26	197.76	308.50	139.41	199.35	236.66	294.90	197.76	139.41

The formulas for eighth scheme of Admiralty Method are:

M2, O2, M4 : W = 0
w = 0
S2 : f = 1
V = 0
u = 0
N2, MS4 : f = f(M2)
u = u(M2)
M4 : f = $f(M2)^2$
V = 2*V(M2)
u = 2*u(M2)
MS4 : V = V(M2)
K2 : A = A(S2)*0.27
g = g(S2)
P1 : A = A(K1)*0.33
g = g(K1)

From the eighth scheme of the Admiralty Method, the type of tidal is then determined using the Formzahl Number (F). The result is:

F =(K1+O1)/(M2+S2)
=(31.37+35.30)/(37.98+6.95)
=1.48

The Formzahl Number (F) of 1.48 defines that the tidal in Bulo coast is mixed tide prevailing semidiurnal type, where F satisfied the criterion: $0.25 < F < 1.5$.

To determine the water elevation, following conditions are used:

MSL = A(S0)
HHWL = Highest High Water Level
LLWL = Lowest Low Water Level
MHWL = MSL + (Range/2)
MLWL = MSL – (Range/2)
Range = 2*(A(M2)+A(S2))

The result is shown on Table XIV.

TABLE XIV
The Water Elevation at Bulo Coast

Elevasi Muka Air	Satuan	Data
HHWL	cm	145.0
MHWL	cm	119.5
MSL	cm	74.6
MLWL	cm	29.7
LLWL	cm	3.0
Range	cm	89.845

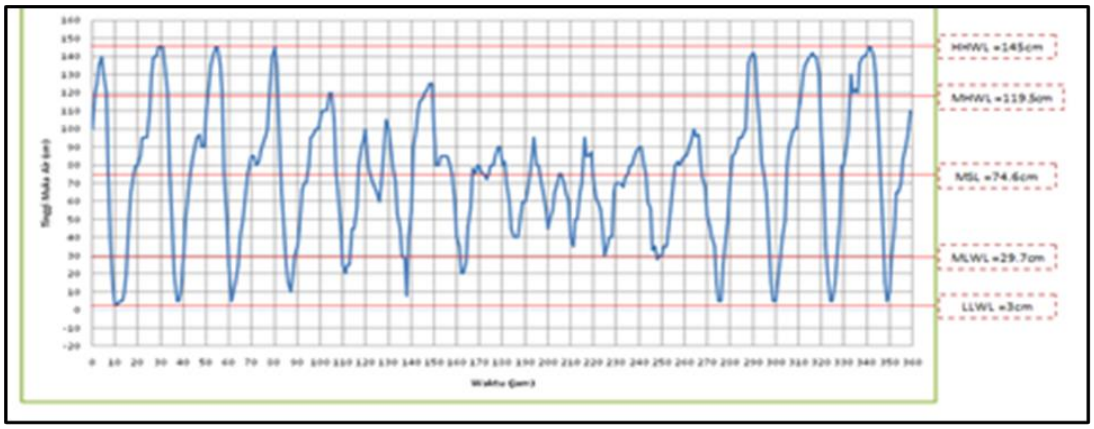

Fig 1: Tidal Graphic of Bulo Coast

V. CONCLUSIONS

Based on the tidal analysis at Bulo coast, the following are the conclusion:

- The tidal type in Bulo coast is mixed tide prevailing semidiurnal type, with the Formzahl Number (F) is 1.48;
- The analysis using Admiralty Method produces tidal constants:

S0=	74.58	O1=	35.30
M2=	37.98	M4=	7.38
S2=	6.95	MS2=	1.5
N2=	27.52	K2=	1.88
K1=	31.37	P1=	10.35

- The mean sea level (MSL) at Bulo coast is 74.58 cm;
- The highest high water level (HHWL) at Bulo coast is 145 cm (+70.4 cm from MSL);
- The lowest low water level (LLWL) at the Bulo coast is 3 cm (-71.6 cm from MSL).

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