

# **Programs to obtain vertical heights from mean sea level and for computing volume of sand/mineral along beaches: A case study with Kalbadevi beach profiling data and results.**

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## **ABSTRACT**

. Two programs have been developed to process beach profile data, for obtaining vertical heights with respect to mean sea level (M.S.L.) and for computation of volume of heavy mineral / sand accumulation or erosion along the beaches. The final output of the first program forms the input for the second program. The listing of the programs is given in this report (Annexures:1 & 2).

Data collected during beach profiling surveys at Kalbadevi bay of Ratnagiri district during February 2004 is used in this report for computation of mineral / sand volume, using the listed programs. Computed volume of sand/mineral accretion / erosion is shown in the form of Table, graphs and bar chart. This ready-reckoner program can be used by geologists to compute the volume of mineral / sand erosion and accumulation along the beaches, wherever such studies are carried out.

## **INTRODUCTION**

The foreshores of the beaches including the surf zone are very interesting as they keep changing time and again. For example, they vary temporarily with changing wave conditions during different seasons having different environmental conditions. Understanding of these seasonal changes are essential to notify erosional and depositional trends, especially for the coastal areas where there is potential for economic activity such as mining of placer deposits. Such studies would indicate the status of seasonal replenishment, which is important to draw mining plans of these placers. The studies on the seasonal variations along the Kalbadevi beach which is a potential site for mining was undertaken under CSIR network project “ Beach Placer mining capacity building “ during different seasons in the years 2004 and 2005. Three beach profiles were studied, one at the northern end, the other at the middle and the third at the southern end of Kalbadevi bay during five different seasons between Feb. 2004 to April 2005. Computation of volume of mineral / sand accretion / erosion along the beaches is required for such studies for geologists working in such areas. Two programs are developed by the author to quantify the change in volume of sand to evaluate the process of accretion and erosion at different parts of the beach. As a case study, a part of Kalbadevi survey data is used in this report and the data has been processed using the two programs listed here. Also, the final processed data using these programs are included in the form of Tables, graphs and bar charts.

## **DESCRIPTION & SCOPE OF STUDY**

Under the CSIR network project on “Beach placer mining capacity building”, NIO has identified Kalbadevi Bay in Maharashtra along central west coast of India, as a potential site for placer mining in future. Kalbadevi stretch is 5.5 kms.

long and ~250 m. wide, with estuaries on both northern and southern ends of the bay. One of the objectives of this project was to understand the environmental conditions in the areas of potential deposits, to prepare an environmental management plan and to compute the quantity of sand/mineral deposit in the study area. During the period from February 2004 to April 2005, to meet the requirements of the project, the following studies were conducted at Kalbadevi bay (from survey point of view) in three phases.

- i) Shoreline identification and demarcation of high tide line
- ii) Establishing permanent bench marks at three selected places along Kalbadevi bay for carrying out beach profiles
- iii) Beach profile studies with collection of field data.

The main purpose for undertaking this study was to compare the beach profiles done at different periods, using the newly developed programs in GWBASIC language.

The benchmark pillars were established at three different locations along the Kalbadevi beach under study. These are BP1 (northern end), BP2 (Central ) and BP3 (southern end). The Differential Global Position Fixing system (Trimble DGPS-4000) was used to obtain the geographical co-ordinates. A total of 15 profiles were surveyed at these three different locations (5 profiles on each location at different seasons). As indicated in Table:1, the standard survey procedures were used to carryout the profiling as described by Ganeshan (2004). Only one profile at Northern end (**B.P. :1**) of Kalbadevi bay is used for case study in this report whose geographical location is given below:

Bench mark Pillar No	Position in WGS-1984		Position in Indian -1975		Remarks
	Latitude (N)	Longitude (E)	Latitude (N)	Longitude (E)	
BP - 1	17 04 03.994	73 17 19.439	17 03 59.681	73 17 18.325	at Northern end

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## SOFTWARES DEVELOPED

- I) Program for obtaining vertical heights along profiles from mean sea level. (M.S.L.)
- II) Program for obtaining volume of sand / mineral along profiles from M.S.L.

The listing of the software is given in Annexure: I and Annexure :2 of this report.

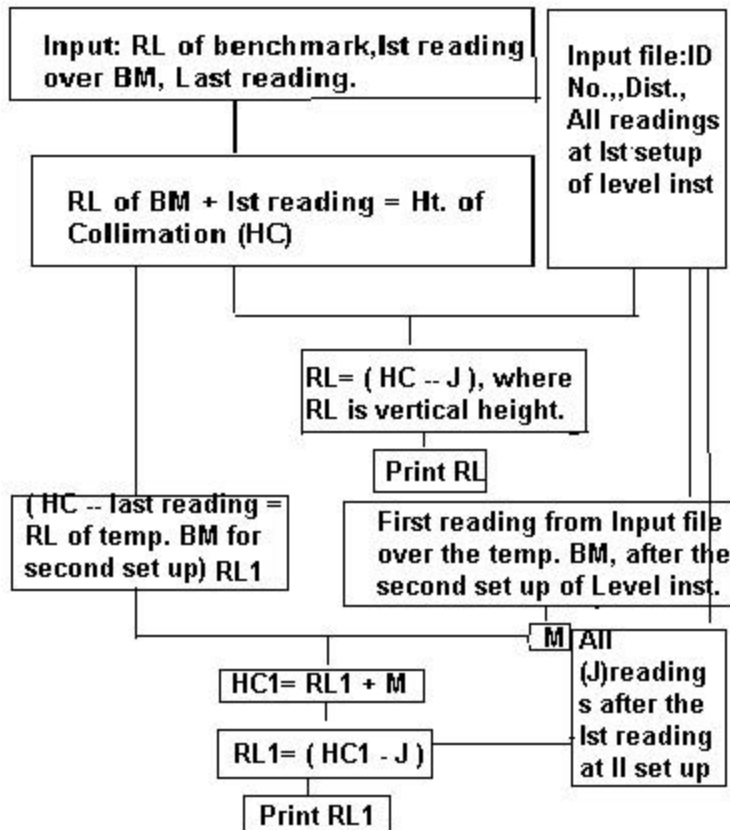
## LOGIC AND FLOW DIAGRAM

The logic used in first program “Program to obtain vertical heights along profiles from M.S.L.” is given below:

The reduced level over the bench mark pillar (BP:1 in this case, from where the profile starts) should be added with the first staff reading taken over it, which forms the height of collimation (H.C.) of the instrument. From this H.C., all the successive staff readings (taken at regular distance interval, along the profile) should be deducted to get the vertical heights (called reduced level (R.L.) in survey terms).

- i)  $\text{R.L. at benchmark pillar} + \text{staff reading over the benchmark (BM) pillar} = \text{Height of Collimation of instrument (H.C.)}$
- ii)  $\text{H.C. at first set up} - \text{successive staff readings} = \text{Reduced levels (Vertical heights with respect to M.S.L.) of successive points along the profile.}$
- iii)  $\text{Height of Collimation of inst. (HC1) at second set up} = \text{Reduced level of last point (Temp BM)} + \text{First staff reading (immediately after second set up) over Temporary benchmark.}$
- iv)  $\text{Reduced level of all successive data points from second set up} = (\text{HC1} - \text{successive staff readings observed from second set up})$

The logical flow diagram is given below



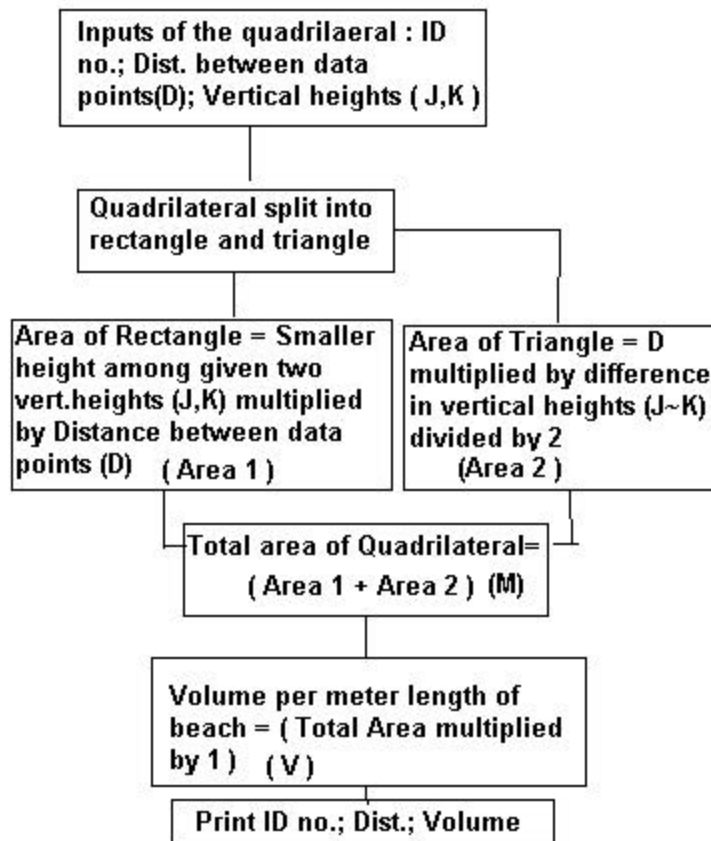
**Fig.1** Flow chart for obtaining vertical heights with respect to mean sea level, on staff readings observed through an automatic level instrument.

The logic used in second program “Program for obtaining volume of sand / mineral along profiles from M.S.L..” is given below :

The main input for this program is vertical heights reduced to mean sea level (which was obtained through the first program listed here) and the distance interval between successive locations along the profile.

The logic of computation is 1) Along the profile from the benchmark pillar, quadrilateral blocks are made at distance interval. Consequently we have two vertical heights and one distance between two successive locations. along the profile (from mean sea level). So it becomes a quadrilateral, whose area can be computed by splitting the quadrilateral into a rectangle and a right angled triangle (See Fig. 3). Area of the rectangle = (K × D) or (J × D) where “K” or “J” is the smallest vertical height among J

and K. Area of the right angled triangle =  $\frac{1}{2} (a \times D)$ , where “a” is the vertical side of the triangle (obtained by getting the difference from the two vertical sides of the quadrilateral, (J~K) and “D” is the distance between data points. The total of the above two parts gives the area of the quadrilateral. Volume of sand / mineral can be computed by multiplying the area of the quadrilateral into 1 meter length of the beach, which gives volume in cu.meters per meter length of beach.



**Fig. 2** Flow chart for quantification of volume of sand/mineral, based on vertical heights with respect to mean sea level.

## RESULTS AND DISCUSSIONS

The developed Programs (in GWBASIC language) are useful for processing the beach profile field data. Earlier, computation of vertical heights were done manually by surveyors and technicians, which was time consuming for processing the field data. The first Program (See Annexure:1) computes the vertical heights with respect to mean sea

level along beach profiles, which saves lot of time in processing the field data. The second Program (See Annexure:2) solves the problem of computation of volume of sand / mineral along the beach profiles. This enables scientists to compute overall volume of sand / mineral in the study area. Comparison of these volumes at different study seasons gives quantity estimate of deposition and erosion at the study area. By effectively using the above two softwares, the final results of a portion of Kalbadevi bay are shown in this report, in the form of Tables (Table:1), line graphs (Fig. 4) and bar charts (Figures:5 & 6).

### **Acknowledgement**

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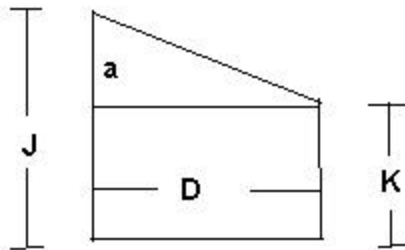
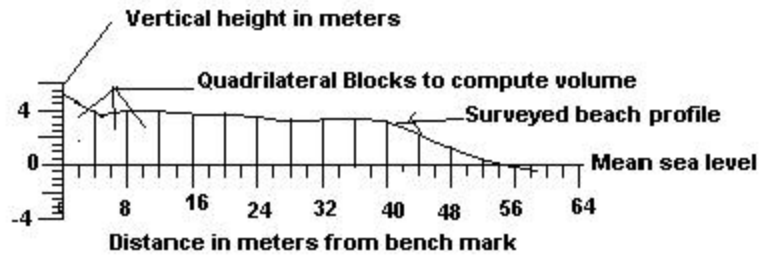
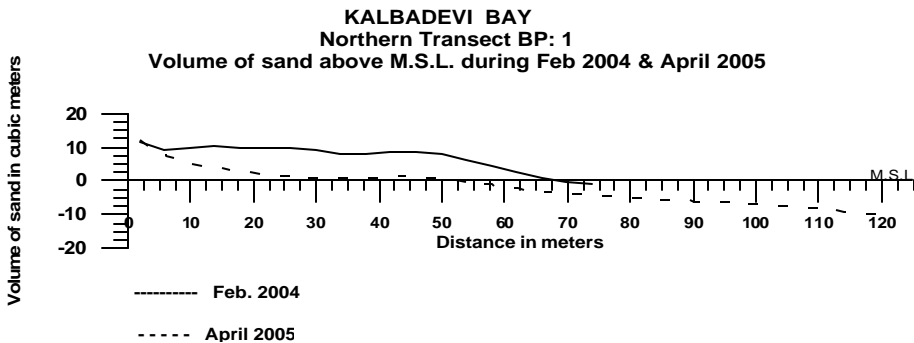
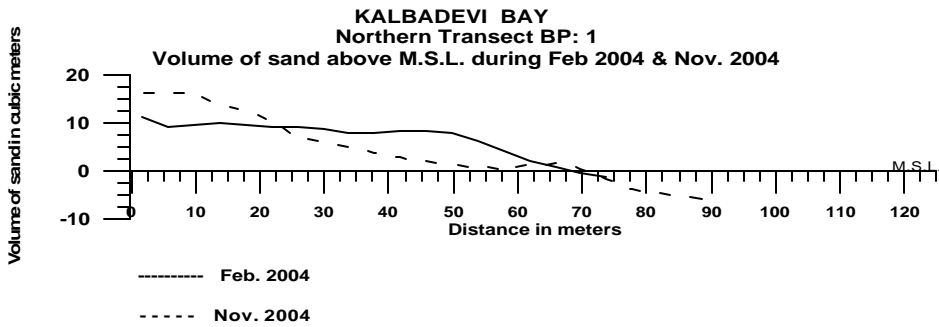
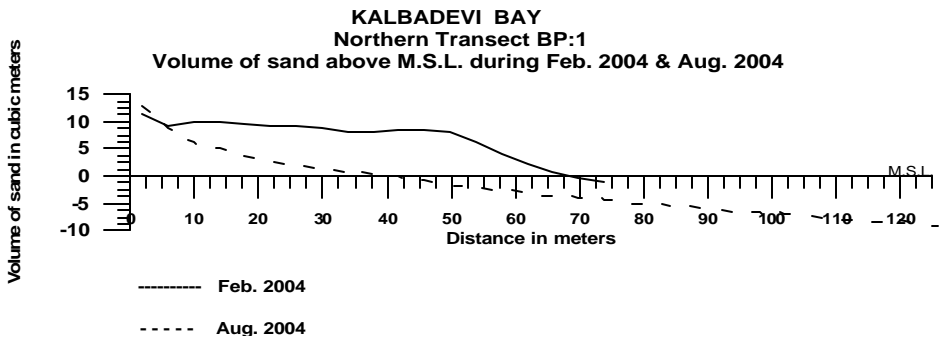
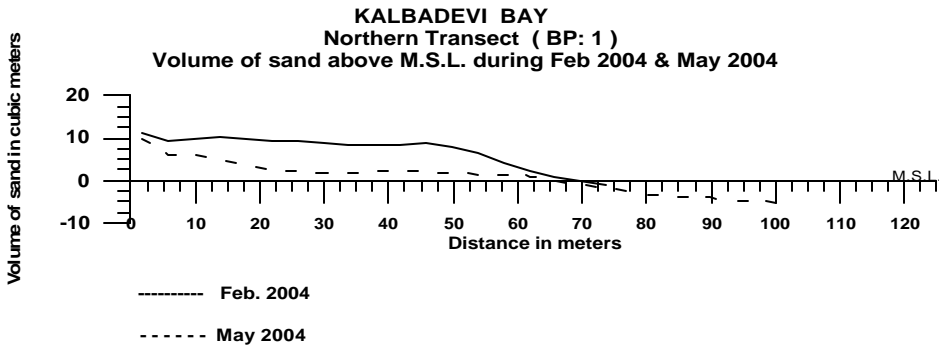


Fig. 3 (a) A beach profile graph shown with respect to mean sea level. The profile is split into quadrilateral blocks of 4 meters length (along the profile), for computing the volume of sand/mineral for one meter length of the beach, using the second program.

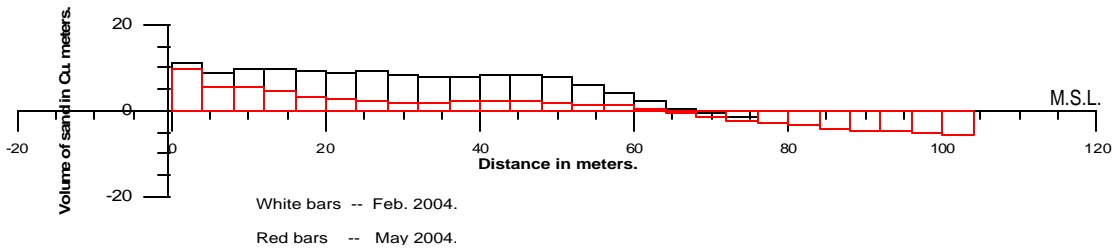
(b) Cross sectional view of one quadrilateral block of “D” meters length (4 mts. in this case) of the profile. “J” and “K” are the vertical heights of sand/mineral from mean sea level at every “D” meters interval. “a” shows the difference in vertical heights of every successive data point.



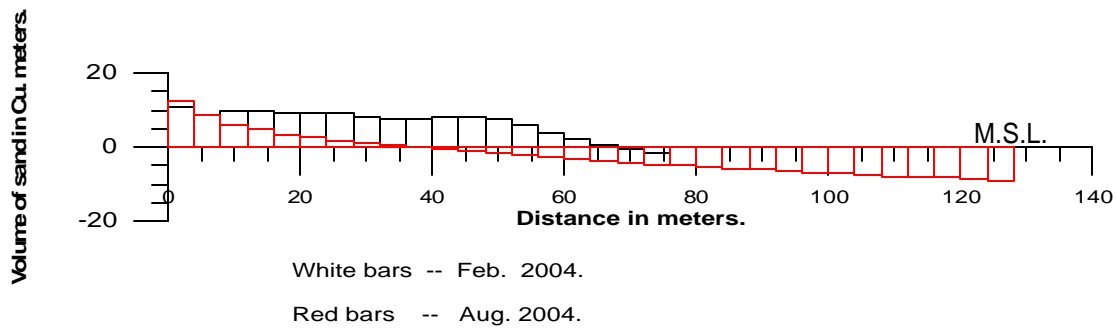


**Fig. 4 Beach profiles of various seasons super imposed on Feb. 2004 (First season) data at Northern Transect BP:1 of Kalbadevi bay at Ratnagiri Dt.**

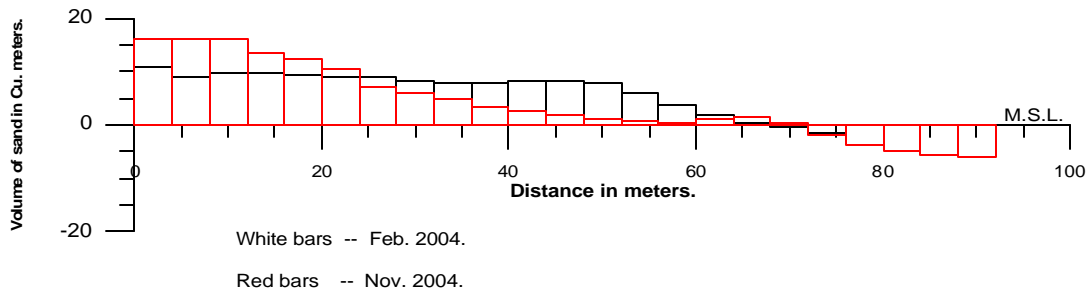
**KALBADEVI BAY  
NORTHERN TRANSECT (BP:1)  
VOLUME OF SAND COMPARISON CHART BETWEEN FEB. 2004 & MAY 2004.**



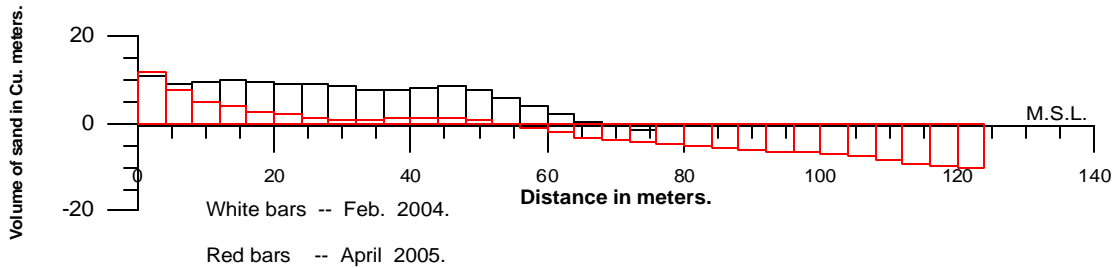
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NORTHERN TRANSECT (BP:1)  
VOLUME OF SAND COMPARISON CHART BETWEEN FEB. 2004 & AUG. 2004.**



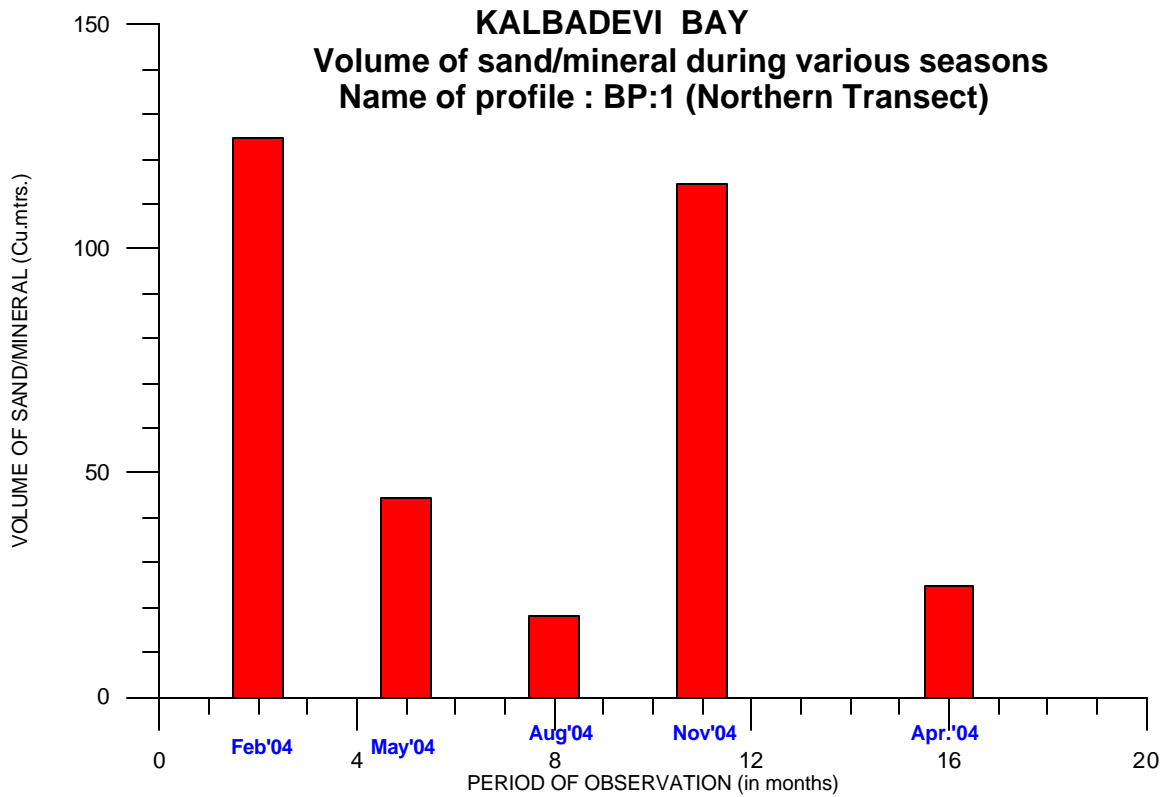
**KALBADEVI BAY  
NORTHERN TRANSECT (BP:1)  
VOLUME OF SAND COMPARISON CHART BETWEEN FEB. 2004 & NOV. 2004.**



**KALBADEVI BAY  
NORTHERN TRANSECT (BP:1)  
VOLUME OF SAND COMPARISON CHART BETWEEN FEB. 2004 & APRIL 2005.**



**Fig. 5 Bar charts showing clearly the difference in volume of sand / mineral at Northern Transect (BP:1) of Kalbadevi bay (Ratnagiri Dt.)**



**Fig. 6** Figure shows the bar chart prepared using the output derived from the second Program. The bar chart shows clearly the volume of sand/mineral erosion and Deposition during various seasons (Feb.2004 to April 2005) of the study made at Kalbadevi bay (Ratnagiri Dt.).

**TABLE : 1**

**Final volume of sand / mineral at BP: 1 (Northern Transect) at Kalbadevi Bay.**  
 (The following results are obtained using the above softwares developed by the author)

<b>Dist. from B.M.</b>	<b>Feb. 2004</b>	<b>May 2004</b>	<b>Aug. 2004</b>	<b>Nov. 2004</b>	<b>Apr. 2005</b>
4	10.946	9.56	12.44	16.17	11.91
8	8.864	5.67	8.68	16.203	7.68
12	9.552	5.73	5.92	16.09	4.782
16	9.77	4.63	4.74	13.678	3.82
20	9.264	3.17	3.24	12.503	2.698
24	8.988	2.596	2.52	10.428	1.952
28	8.992	2.146	1.87	7.053	1.322
32	8.436	1.724	1.18	5.99	0.76
36	7.79	1.754	0.646	4.865	0.694
40	7.752	2.22	0.212	3.49	1.064
44	8.178	2.42	-0.398	2.615	1.296
48	8.354	2.16	-1.034	1.803	1.116
52	7.69	1.63	-1.624	1.227	0.578
56	5.914	1.41	-2.182	0.715	-0.186
60	3.868	1.31	-2.702	0.528	-1.14
64	2.024	0.55	-3.208	1.015	-2.222
68	0.474	-0.53	-3.718	1.428	-3.176
72	-0.57	-1.476	-4.128	0.415	-3.85
76	-1.39	-2.266	-4.508	-1.948	-4.38
80		-2.924	-4.938	-3.948	-4.8
84		-3.504	-5.342	-4.843	-5.2
88		-4.046	-5.742	-5.48	-5.61
92		-4.506	-6.128	-5.88	-6.01
96		-4.89	-6.458		-6.39
100		-5.27	-6.756		-6.77
104		-5.7	-7.066		-7.18
108			-7.402		-7.68
112			-7.796		-8.38
116			-8.222		-9.2
120			-8.222		-9.75
124			-8.658		-10.13
128			-9.148		
132					
<b>Total</b>	<b>124.896</b>	<b>44.408</b>	<b>17.946</b>	<b>114.268</b>	<b>24.718 (Cu.mtrs.)</b>
	(Volume in Cubic meters up to 76 meters width of beach from B.M.)				

## ANNEXURE :1

### Program for obtaining vertical heights along profiles from M.S.L.

The following program is developed to process the beach profile field data collected using Level instrument at Kalbadevi bay.

```
5  REM PROGRAM TO GET VERTICAL HEIGHTS ON BEACH PROFILES FROM M.S.L.
10 DEFDBL J-Z
15 AB$ = " ###  ##.#  ##.### "
20 CD$ = " ###  ##.#  ##.### "
25 PRINT "PROGRAM TO GET VERTICAL HEIGHTS WITH RESPECT TO M.S.L."
30 PRINT "KALBADEVI BAY, RATNAGIRI DT., CENTRAL WEST COAST OF INDIA"
35 PRINT
40 PRINT "-----"
45 PRINT " FIX NO.  DIST.      REDUCED LEVEL "
50 PRINT "      FROM B.M.  VERT.HEIGHTS FROM M.S.L."
55 PRINT
60 PRINT "GIVE INPUT FILE NAME":INPUT INFILE$
65 OPEN  INFILE$ FOR INPUT AS #1
70 OPEN "BP2MAY.OUT" FOR OUTPUT AS #7
75 PRINT #7,"          "
80 PRINT #7,"PROGRAM TO GET BERTICAL HEIGHTS WITH RESPECT TO M.S.L."
85 PRINT #7,"          "
90 PRINT #7," FIX NO.  DIST.      REDUCED LEVEL      "
95 PRINT #7,"-----"
100 PRINT #7,"          "
105 FOR I=1 TO 20
110 INPUT #1, F,D,J
115 IF F > 10 THEN GOTO 175
120 REM K= REDUCED LEVEL OF B.M. FROM WHERE THE PROFILE STARTS.
125 REM L= FIRST READING OBSERVED ON B.M. AFTER SETTING UP LEVEL INST.
130 REM M= LAST READING OBSERVED BEFORE SHIFTING LEVEL INST.
135 REM N= FIRST READING OBSERVED AT SECOND SET UP.
140 K = 3.16
145 L = .185
150 M = 1.952
```

```

155 N = .6
160 HC = (K+L)
165 RL = (HC-J)
170 GOTO 185
175 HC = ((K+L-M)+N)
180 RL = (HC-J)
185 PRINT "          "
190 PRINT USING AB$;F,D,RL
195 PRINT #7, USING CD$;F,D,RL
200 PRINT #7,"          "
205 NEXT
210 PRINT "END OF DATA."
215 END

```

---

In the above program,

**F** = Identification number

**D** = Distances from Bench Mark (B.M.) to every data point along the profile.

**J** = Vertical heights observed using Level inst. (Intermediate sight) at specified dist. Intervals (D)

**RL** = Final processed vertical heights from M.S.L. (Reduced Levels of every survey point)

**K** = Known vertical height (from M.S.L.) of the point from where profile starts (Called as “bench mark” in survey terms),

**L** = First reading taken over bench mark after setting up the inst. (Called as “Backsight” in survey terms).

**M** = Last reading taken before changing the instrument station. (Called as “Foresight” in survey terms).

**N** = First reading taken after shifting the inst. and setting up at different location.

---

**The input file for the above Program is given below:**

[ First column; Identification No.

Second column: Distance from the starting point of the profile in meters.

Third column: Vertical staff reading observed through Level inst. along the profile. ]

1,0,0.185  
2,4,1.290  
3,8,1.408  
4,12,1.483  
5,16,1.595  
6,20,1.715  
7,24,1.815  
8,28,1.875  
9,32,1.950  
10,36,1.952  
11,40,0.395  
12,44,0.363  
13,48,0.360  
14,52,0.540  
15,56,0.575  
16,60,0.685  
17,64,0.635  
18,68,0.552  
19,72,0.800

---

**The final output file after processing the field data is given below:**

PROGRAM TO GET VERTICAL HEIGHTS WITH RESPECT TO M.S.L.

FIX NO. DIST. REDUCED LEVEL

---

1	0.0	3.160
2	4.0	2.055
3	8.0	1.937
4	12.0	1.862
5	16.0	1.750
6	20.0	1.630
7	24.0	1.530
8	28.0	1.470

9	32.0	1.395
10	36.0	1.393
11	40.0	1.598
12	44.0	1.630
13	48.0	1.633
14	52.0	1.453
15	56.0	1.418
16	60.0	1.308
17	64.0	1.358
18	68.0	1.441
19	72.0	1.193

---



## ANNEXURE : 2

### Program for obtaining volume of sand / mineral along profiles from M.S.L.

The listing of the program is given below:

```
5  REM PROGRAM TO COMPUTE VOLUME OF HEAVY MINERAL/SAND ON BEACH
   PROFILES
10  DEFDBL J-Z
15  AB$ = "####   ###.### "
20  CD$ = "####   ###.### "
25  PRINT "VOLUME OF HEAVY MINERAL/SAND COMPUTATION PER METER
      LENGTH OF BEACH"
30  PRINT "KALBADEVI BAY, RATNAGIRI DT., CENTRAL WEST COAST OF INDIA"
35  PRINT
40  PRINT "-----"
45  PRINT "BLOCK NO.  VOLUME OF HEAVY MINERAL/SAND IN Cu.Mtrs."
50  PRINT "-----"
55  PRINT
60  PRINT "GIVE INPUT FILE NAME":INPUT INFILE$
65  OPEN INFILE$ FOR INPUT AS #1
70  OPEN "APRIL1.OUT" FOR OUTPUT AS #7
75  PRINT #7,"
80  PRINT #7,"VOLUME OF HEAVY MINERAL/SAND PER METER LENGTH OF BEACH"
85  PRINT #7,"
90  PRINT #7," BLOCK NO.  VOLUME (Cu.m.)          "
95  PRINT #7,"-----"
100 PRINT #7,"
105 FOR I=1 TO 32
110 INPUT #1, F,D,J,K
115 IF F < 1 THEN GOTO 185
120 IF K > J THEN GOTO 145
125 L = (J-K)
130 M = (K*D)+(L*(D/2))
135 V = (M*1)
140 GOTO 160
145 L = (K-J)
150 M = (J*D)+(L*D/2)
155 V = (M*1)
160 PRINT "
165 PRINT USING AB$;F,V
170 PRINT #7, USING CD$;F,V
175 PRINT #7,"
180 NEXT
185 END
```

---

In the above program,

**F** = Block number (commencing from the Bench mark Pillar over berm or sand dunes)

**D** = Length of the block along the beach profile from B.M., whose volume has to be computed.

**J, K** = Vertical heights of that block from mean sea level.

**M** = Computed area of the block

**V** = Computed final volume of the block per meter length of the beach.

---

**The format of the input file for this program is given below:**

First column: Identification no.

Second column: Distance from starting point (bench mark) along the beach profile.

Third column: Vertical heights of every block from mean sea level.

```
1,4,3.375,2.098
2,4,2.098,2.334
3,4,2.334,2.442
4,4,2.442,2.443
5,4,2.443,2.189
6,4,2.189,2.305
7,4,2.305,2.191
8,4,2.191,2.027
9,4,2.027,1.868
10,4,1.868,2.008
11,4,2.008,2.081
12,4,2.081,2.096
13,4,2.096,1.749
14,4,1.749,1.208
15,4,1.208,0.726
16,4,0.726,0.286
17,4,0.286,-0.049
18,4,-0.049,-0.236
19,4,-0.236,-0.459
```

---

**The final output file after processing the input file** (using the above program) is given below:

VOLUME OF SAND PER METER LENGTH OF BEACH

-----  
BLOCK NO. VOLUME (Cu.m.)  
-----

1	10.946
2	8.864
3	9.552
4	9.770
5	9.264
6	8.988
7	8.992
8	8.436

9	7.790
10	7.752
11	8.178
12	8.354
13	7.690
14	5.914
15	3.868
16	2.024
17	0.474
18	-0.570
19	-1.390

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