RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 5 | Issue 2 | October, 2012 | 147 –152

Life of cement nala bund in Hanjagi watershed

S.K. UPADHYE, V.A. STHOOL, R.V. SANGLIKAR, R.V. MANE, R.K. RATHOD AND J.R. KADAM

Received : 17.04.2012; Revised : 03.07.2012; Accepted : 19.08.2012

See end of the Paper for authors' affiliations

Correspondence to:

J.R. KADAM
All India Coordinated Research Project for Dryland Agriculture, Krishak Bhawan, SOLAPUR (M.S.) INDIA
Email : zars_solapur@rediffmail.com

ABSTRACT : Three cement nala bunds in the village Hanjagi, Tal. Akkalkot, Dist. Solapur were selected for estimation of storage life of cement nala bund in the year 2006. The experimental site Hanjagi watershed is located at 35 km away from Solapur on Solapur-Akkalkot road (diversion from Walsang 10 km). The average annual rainfall of the site is 645 mm. The sediment volume distributed in cement nala bunds was computed by using area –increment –method based on the assumption that the area curve, after sedimentation will be parallel to the original curve. The initial storage capacity of CNB-1, CNB-2 and CNB-3 were 2.699, 3.698 and 4.723 TCM. After completion of six years, the sediment deposited in CNB-1, CNB-2 and CNB-3 were 1867.64 m^3, 1201.30 m^3 and 4103.60 m^3, respectively. Hence, the useful capacity of CNB-1, CNB-2 and CNB-3 were reduced by 69.2 per cent, 32.5 per cent and 83.1 per cent, respectively. The sediment of 172.53 cu. m in the year 2011 was removed from CNB-3 which increased the storage by 3.7 per cent. The storage capacity of CNB-3 was reduced more followed by CNB-1 and CNB-2 according to length of nala *i.e.* 430 m, 360 m and 180 m, respectively and also one big stream and one small stream meet the CNB-3.

KEY WORDS : Life, Cement nala bund, Storage capacity

HOW TO CITE THIS PAPER : Upadhye, S.K., Sthool, V.A., Sanglikar, R.V., Mane, R.V., Rathod, R.K. and Kadam, J.R. (2012). Life of cement nala bund in Hanjagi watershed. *Internat. J. Agric. Engg.*, **5**(2) : 147-152

The rainwater conservation structures are integral part of soil and water conservation programmes and also important component of the watershed development and management programmes. The management of watershed can be viewed as planning and executing the action plan for sustainable development of watershed with minimum hazard to land and water resources of watershed. Since 1983, almost all the development works pertaining to natural resources are being carried out on watershed basis in Maharashtra (Patil, 2003). The water harvesting structures not only control the erosion but also conserve the water. Gule *et al.* (2006) opined that, 117.25 tonnes of soil has been arrested in the nala bund during the period from 1999 to 2002 which has been prevented from going out of watershed alongwith runoff water. Recharging of ground water storage can be effectively done by *in situ* rain water conservation as well as construction of percolation tanks, nala bunding, cement nala bunds, etc. to ensure sustained agricultural production. Nala bunding is one of the important activities of the comprehensive watershed development programme in Maharashtra. Nala bunds are embankments constructed across the nala for storing runoff water, increasing water percolation and improving soil moisture regimes. Embankments which are made of stone masonary are called cement nala plug / bunds.

An estimated average annual soil loss rate of 16.4 t/ha/year on all India basis works out to 5380 Mt soil loss annually. Most of this erosion leads to problems of deposition of silt in reservoir thereby reducing its capacity and useful life. This causes deposition in the large rivers, which leads to reduction in stream slope and this in turn causes problems of flood on banks during high discharge (Atre *et al.*, 2008). The soil loss to a tune of 12626.95 tonnes was estimated to be lost from the croplands of the Kandhamal district at the rate of 94.23 t/ha. It was observed that more soil is eroded from the areas where the land surface is left uncovered in the peak soil eroding season from June to September (Dwitirkishna *et al.*, 2009)

The ultimate destiny of all reservoirs is to get filled with sediment. If the sediment inflow is large in comparison to the reservoir capacity, the useful life of the reservoir may be very short. Jadhav *et al.* (2009) found that the storage capacity of the cement nala plug was reduced by 2.16 per cent in 5 years due to silting with sit retention rate of 24.124 tonnes/year.

Considering the importance of sedimentation, the study was initiated in the year 2006 to determine the annual sediment deposition in cement nala bund. The experimental site is located at Hanjagi watershed, 35 km away from Solapur on

Solapur-Akkalkot road (diversion from Walsang 10 km). Geographically it is situated at $17^0 31' 15''$ N latitude and $76^0 05' 35''$ E longitude. The average annual rainfall of the site is 645 mm.

METHODOLOGY

For estimation of storage life of cement nala bund, three cement nala bunds in the village Hanjagi, Tal. Akkalkot, Dist. Solapur were selected in the year 2006. The average annual rainfall of the site is 645 mm. The existing dimensions of all three cement nala bunds are presented in Table A. The contour maps of all the three nala were prepared before storage of runoff *i.e.* before sediment deposition in structures. The values of surface area, storage capacity with respect to corresponding depth were calculated for CNB-1, CNB-2 and CNB-3 and presented in Table B, C and D, respectively. The maximum water surface area of CNB-1, CNB-2 and CNB-3 were 3510 m^2, 2620 m^2 and 3924 m^2, respectively. The initial maximum storage capacity of CNB-1, CNB-2 and CNB-3 were 2.699 TCM, 3.698 TCM and 4.723 TCM, respectively.The graphical presentation of depth-area-capacity relationship before sedimentation is shown in Fig. A, B and C for the CNB-1, CNB-2 and CNB-3, respectively. The bed levels of nala were taken before and after sediment deposition and are given in Table E, F and G and are shown in Fig. D, E and F. These graphs show the depth of sediment distribution along the bed length of nala.

Table A : Existing dimensions of cement nala bunds under study

Sr. No.	Description	CNB-1	CNB-2	CNB-3
1.	Width of spillway, m	12.00	14.00	19.9
2.	Flow depth, m	0.75	0.7	0.75
3.	Gross free board	1.25	1.00	1.25
4.	Height of water storage, m	1.50	2.00	1.50
5.	Foundation depth, m	1.00	1.00	1.00
6.	Total height of dam, m	2.75	3.00	2.75
7.	Top width of dam, m	0.97	1.05	0.90
8.	Bottom width of dam, m	2.05	2.40	1.70
9.	Height of water cushion, m	0.40	1.10	1.50
10.	Width of water cushion, m	2.30	3.00	2.30
11.	Length of water cushion, m	14.00	16.00	22.40
12.	Length of header wall, m	13.90	15.90	22.40
13.	Width of header wall, m	0.60	0.65	0.65
14.	Key wall width, m	0.95	1.05	0.82
15.	Key wall height, m	2.75	3.00	2.75
16.	Key wall length, m	0.50	0.72	1.20
17.	Length of wing wall, m	4.55	4.55	4.45
18	Length of side wall, m	4.35	4.20	4.15
19.	Total length of dam, m	17.00	18.60	25.50
20.	Volume of storage, TCM	2.699	3.698	4.723

Table B : Depth-area-capacity values for CNB-1

Sr. No.	Depth (m)	Area (m^2)	Capacity (m^3)
1.	0	389	0.00
2.	0.3	549	140.70
3.	0.6	1144	394.65
4.	0.9	1923	854.70
5.	1.2	3433	1658.10
6.	1.5	3510	2699.55

Table C : Depth-area-capacity values for CNB-2

Sr. No.	Depth (m)	Area (m^2)	Capacity (m^3)
1	0	693	0.00
2	0.5	1480	543.25
3	1.0	1964	1404.25
4	1.5	2296	2469.25
5	2.0	2620	3698.25

Table D : Depth-area-capacity values for CNB-3

Sr. No.	Depth (m)	Area (m^2)	Capacity (m^3)
1.	0.0	1935	0.00
2.	0.5	2951	1221.50
3.	1.0	3567	2851.00
4.	1.5	3924	4723.75

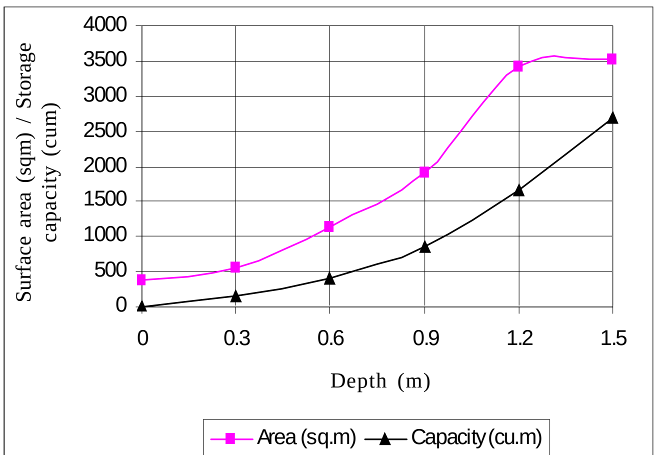

Fig. A : Depth-area-capacity curve for CNB-1

The Sediment volume distributed in cement nala bunds was computed by using 'area –increment –method' which is purely mathematical procedure based on the assumption that the area curve, after sedimentation will be parallel to the original curve. This means that the sediment area is constant at all elevations and the sediment volume is uniformly distributed vertically above the new zero elevation. For estimation of sediment volume in the cement nala bund the

Table E : Bed levels of cement nala bund-1

Distance, m	I .B.L. 2006	B.L 2007	B.L. 2008	B.L. 2009	B.L. 2010	B.L. 2011	B.L. 2012	Ele. Diff. (m)
0	97.21	97.225	97.23	97.28	97.61	97.81	97.81	0.60
30	97.11	97.4	97.42	97.4	97.59	97.74	97.74	0.63
60	97.52	97.575	97.595	97.6	97.67	97.80	97.80	0.28
90	97.65	97.785	97.799	97.8	97.81	97.90	97.90	0.25
120	97.81	97.82	97.91	97.91	97.93	97.99	97.99	0.18
150	97.79	97.92	97.99	97.99	98.05	98.08	98.08	0.29
180	97.83	97.96	98.03	98.041	98.18	98.23	98.23	0.40
210	98.11	98.27	98.28	98.28	98.31	98.39	98.39	0.28
240	98.16	98.37	98.41	98.41	98.43	98.52	98.52	0.36
270	98.1	98.41	98.45	98.45	98.5	98.61	98.61	0.51
300	98.17	98.45	98.448	98.51	98.56	98.68	98.68	0.51
330	97.75	98.635	98.64	98.64	98.67	98.76	98.76	1.01
360	98.35	98.635	98.68	98.7	98.73	98.83	98.83	0.48
B.Slope,%	0.32	0.39	0.4	0.39	0.31	0.28	0.28	-
Average depth of sediment deposition during 6 years, m								0.44

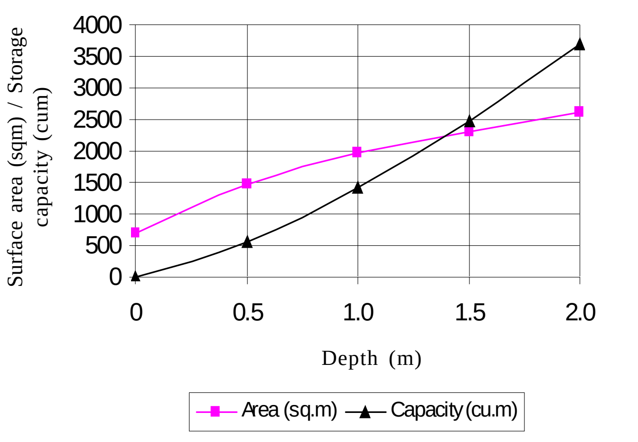

Fig. B : 2 Depth-area-capacity curve for CNB-2

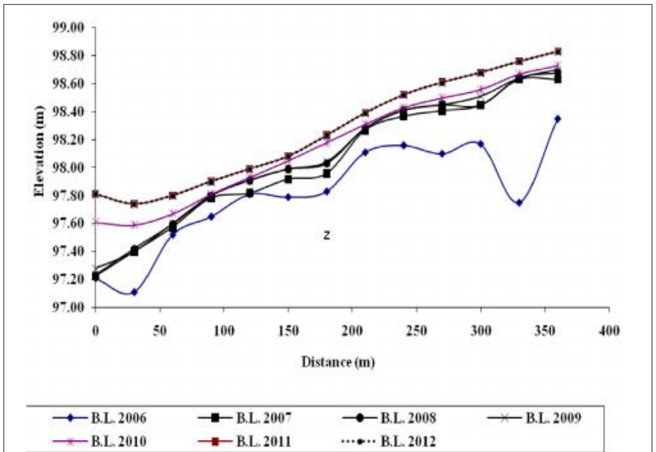

Fig. D : Sediment deposition in CNB-1

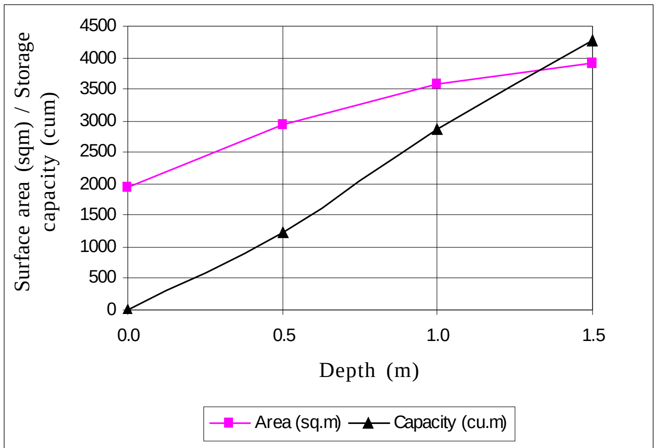

Fig. C : Depth-area-capacity curve for CNB-3

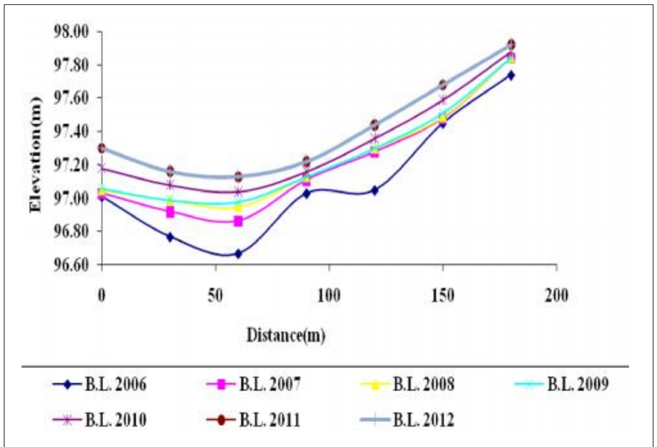

Fig. E : Sediment deposition in CNB-2

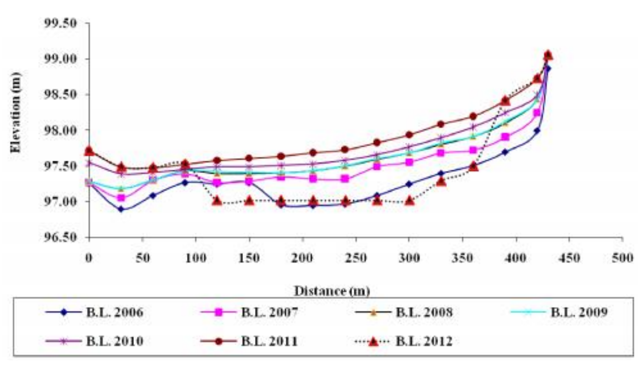

Fig. F : Sediment deposition in CNB-3

following equation was used

$$VS = A_O (H - H_O) + V_O$$

where,

V_S = Sediment volume to be distributed, m^3

V_o = Sediment below the new zero elevation, m^3

H = Original reservoir depth from the stream bed level, m

H_o = Height to which the reservoir completely filled with sediment (*i.e.* height of new zero elevation),m

A_o = Surface area of the reservoir at the new zero elevation, m^2

The volume of sediment deposited in three CNBs from the year 2006-2011 is presented in Table J.

Table F : Bed levels of cement nala bund-2

Distance, m	I .B.L. 2006	B.L. 2007	B.L. 2008	B.L. 2009	B.L. 2010	B.L. 2011	B.L . 2012	Ele. Diff. (m)
0	97.01	97.03	97.05	97.06	97.18	97.30	97.30	0.29
30	96.77	96.92	96.99	96.99	97.08	97.16	97.16	0.39
60	96.67	96.865	96.95	96.98	97.04	97.13	97.13	0.46
90	97.03	97.11	97.13	97.13	97.16	97.22	97.22	0.19
120	97.05	97.28	97.3	97.3	97.36	97.44	97.44	0.39
150	97.45	97.48	97.49	97.51	97.59	97.68	97.68	0.23
180	97.74	97.84	97.845	97.84	97.88	97.92	97.92	0.18
B. Slope,%	0.4	0.45	0.44	0.43	0.38	0.34	0.34	-
Average depth of sediment deposition during 6 years, m								0.30

Table G : Bed levels of cement nala bund-3

Distance, m	I .B.L. 2006	B.L. 2007	B.L. 2008	B.L. 2009	B.L. 2010	B.L. 2011	B.L. 2012	Ele. Diff. (m)
0	97.26	97.27	97.29	97.29	97.55	97.72	97.72	0.46
30	96.9	97.055	97.19	97.19	97.39	97.49	97.49	0.59
60	97.09	97.3	97.31	97.31	97.41	97.48	97.48	0.39
90	97.27	97.39	97.44	97.44	97.45	97.53	97.53	0.26
120	97.25	97.27	97.4	97.43	97.49	97.58	97.02	-0.23
150	97.27	97.29	97.4	97.42	97.49	97.61	97.02	-0.25
180	96.96	97.35	97.41	97.41	97.51	97.64	97.02	0.06
210	96.95	97.32	97.44	97.44	97.53	97.69	97.02	0.07
240	96.97	97.32	97.505	97.51	97.58	97.73	97.02	0.05
270	97.09	97.495	97.6	97.61	97.66	97.83	97.02	-0.07
300	97.25	97.555	97.69	97.69	97.77	97.94	97.02	-0.23
330	97.4	97.685	97.81	97.83	97.9	98.09	97.30	-0.1
360	97.51	97.725	97.92	97.92	98.05	98.20	97.50	-0.01
390	97.7	97.905	98.11	98.13	98.25	98.42	98.42	0.72
420	98	98.25	98.44	98.44	98.5	98.73	98.73	0.73
430	98.87	99.04	99.03	99.03	99.04	99.06	99.06	0.19
B.Slope,%	0.37	0.41	0.4	0.4	0.35	0.30	0.31	
Average depth of sediment deposition during 6 years, m								0.16

Table H : Components of 'area-increment-method' for sediment deposition in cement nala bunds

Sr. No.	Components	CNB-1	CNB-2	CNB-3
1.	Original depth, (H), m	1.50	2.00	1.50
2.	Average depth of sediment deposition, m	0.44	0.30	0.16
3	Average depth of sediment removed, m	--	--	0.71
4.	New depth, (H_o), m	0.851	1.622	0.968
5.	Surface area at new depth, (A_o), m^2	1280	1320	3000
6.	Sediment below the new zero elevation, m^3	1036.92	702.34	2507.6

Table I : Sediment deposition in cement nala bunds by 'area-increment-method'

Sr. No.	Parameters	CNB-1	CNB-2	CNB-3
1.	Sediment density, kg m^{-3}	1390.00	1250.00	1260.00
2.	Sediment volume deposited (2010-2011), m^3	1867.64 (69.2)	1201.30 (32.5)	4103.60 (86.8)
3.	Sediment volume removed, m^3	--	--	172.53 (3.7)
3.	Original capacity, m^3	2699.55	3698.25	4723.75
4.	Remaining capacity, m^3	831.91 (30.8)	2496.95 (67.5)	792.68 (16.8)

N.B. : Figures in the parenthesis indicate per cent volume

Table J : Sediment volume deposition in cement nala bunds over the years

Sr. No.	Year	Rainfall, mm	Rainy days, Nos.	Sediment volume deposited , m^3		
				CNB-1	CNB-2	CNB-3
1.	2005-2006	--	--	0	0	0
2.	2006-2007	351.2	26	102.52 (3.79)	91.74 (2.48)	507.36 (10.74)
3.	2007-2008	440.3	26	487.92 (18.0)	344.74 (9.3)	2097.36 (44.4)
4.	2008-2009	271.1*	21	487.92 (18.0)	344.74 (9.3)	2097.36 (44.4)
5.	2009-2010	581.9	37	1036.92 (38.4)	702.34 (19.0)	2507.60 (53.0)
6.	2010-2011	549.5	45	1867.64 (69.2)	1201.30 (32.5)	4103.60 (86.8)
7.	2011-2012	250.3*	12	1867.64 (69.2)	1201.30 (32.5)	4103.60 (86.8)
	Avg. volume of sediment deposition m^3/year (6 years)			311.27 (11.53)	200.22 (5.42)	683.93 (14.47)
	Avg. volume of sediment deposition m^3/year (4 years)			466.91 (17.30)	300.33 (8.13)	1025.90 (21.70)
	Original capacity, m^3			2699.55	3698.25	4723.75

N.B. - Figures in the parenthesis indicate percent volume .
- * There was no runoff in these years

RESULTS AND DISCUSSION

The average depth of sediment distributed in CNB-1, CNB-2 and CNB-3 was 0.44 m, 0.30 m and 0.16 m, respectively. The initial average bed slope of nala was 0.32, 0.40 and 0.37 per cent and after six years of sediment deposition, it was 0.28, 0.34 and 0.30 per cent, respectively.

The various components of the 'area-increment method' for estimation of sediment deposition are presented in Table H8. The total volume of sediment deposited in CNB-1, CNB-2 and CNB-3 is given in Table I, which was 1867.64 m^3, 1201.30 m^3, and 4103.60 $m^{3,}$ respectively. In the year, 2008-09 and 2011-2012, there was only 271.7 mm and 250.3 mm rainfall in 21 and 12 days, respectively. This rainfall did not cause runoff, hence, there were no sedimentation during this two years. During year 2011, 172.53 m^3 sediment from CNB-3 was removed by the farmers of the village and used for spreading on the field which increased the storage capacity of the CNB-3 by 3.7 per cent.

The useful capacity of CNB-1, CNB-2 and CNB-3 were reduced by 69.2 per cent, 32.5 per cent and 83.1 per cent, respectively after a period of six years. The storage capacity of CNB-3 was reduced more followed by CNB-1 and CNB-2 according to length of nala *i.e.* 430 m, 360 m and 180 m, respectively and also one big stream and one small stream meet the CNB-3.

Conclusion:

The useful capacity of CNB-1, CNB-2 and CNB-3 were reduced by 69.2 per cent, 32.5 per cent and 83.1 per cent, respectively due to sedimentation. The average rate of sediment deposition in CNB-1, CNB-2 and CNB-3 were 466.91, 300.33 and 1025.90 cu.m per year which reduced the storage /

useful capacity of CNB-1, CNB-2 and CNB-3 by 17.30, 8.13 and 21.70 per cent per year, respectively. When the years in which the rainfall producing runoff are considered, it may be concluded that, the storage life of CNB-1, CNB-2 and CNB-3 will be 6 , 12 and 5 years, respectively.

For sustaining the useful life of cement nala bunds following suggestions are made :

– The suitable soil and water conservation treatments should be carried out on watershed basis to reduce the soil erosion.

– The silt deposited in the cement nala bunds should be removed regularly to maintain its storage capacity and the removed silt has to be preferred for crop lands having shallow soils with low water holding capacity.

– User group / beneficiary group of the farmers should be formed to take the care and maintenance of the cement nala bunds.

Authors' affiliations:

S.K. UPADHYE, V.S. STHOOL, R.V. SANGLIKAR AND R.K. RATHOD, All India Coordinated Research Project for Dryland Agriculture, Krishak Bhavan, SOLAPUR (M.S.) INDIA

R.V. MANE, Department of Soil, Water Conservation Engineering, College of Agriculture, SOLAPUR (M.S.) INDIA

REFERENCES

Atre, A.A., Bangal, G.B. and Bote, N.L. (2008). Watershed management works influencing the soil loss rates from watershed. Proceedings of National Seminar on Soil, Water conservation and crop management under rainfed agriculture held at ZARS, Solapur (M.S.) on 29-30 August 2008. pp. 44-48

Dwitirkishna P., Acharya, M. and Senapati, P. C. (2009). Estimation of soil loss from crop lands of Kandhamal plateau in Orissa. *Indian J. Dryland Agric. Res. & Dev.,* **24**(1):52-56.

Gule, S.B., Pawar, S.N., Kamble, A.M., Pawar, R.B. and Bhuibhar, B.W. (2006). Evaluation of earthen nala bund in Khandala watershed (M.S.). *Indian J. Dryland Agric. Res. & Dev.,* **2**(1):53-59.

Jadhav, S.B., Kalbande, S.R. and Vikhe, S.D. (2009). Evaluation of cement nala plug. *ARPN J. Engg. & Appl. Sci.,* **4** (1):88-91.

Patil, V.D. (2003). Watershed development programme in Maharashtra. Lecture note in ICAR short term course on " Integrated approach to watershed-tank and command area" held at Parbhani (M.S.) during October 6-15, 2003.

***