Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 2, February -2017

Hydrological Study of Bhadar River Basin in Saurashtra region, Gujarat

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Abstract:- *Saurashtra is a less rainfall receiving region of Gujarat state with considerably low scanty rainfall. Further topography of Saurashtra is like back of Tortoise so it has increased runoff and most of the rainwater gets lost in form of runoff. Though consists of many rivers, the region of Saurashtra feels acute water crisis as most of these rivers are seasonal. Bhadar River is a river in the Saurashtra peninsula, in the Western Indian state of Gujarat. It flows south from its origin through Jasdan, then turns south-west and generally west until it empties into the Arabian Sea. It is impounded by two reservoirs, Bhadar-I reservoir with a capacity of 238 MCM (193,000 acre·ft), and downstream from that, Bhadar-II reservoir with a capacity of 49 MCM (40,000 acre·ft). Also some preliminary secondary data analysis is presented. Here an attempt is made to carry out over all study of Bhadar river system and basin.*

Key Words: *River Basin, Morphometry, Sediment, tropical*

1. INTRODUCTION

Rivers are the most precious and important primary source of natural water. It is a key feature for development for any society. In tropical country like India where monsoon is restricted to some specific time period and rainfall is non-uniform as well as scanty, most of the rivers dry up after few months from end of monsoon season hence very few rivers are perennial. In Saurashtra also most of the rivers dry up in the summer. The river originates from the central Saurashtra in the Chotila range flow to the south into the desert of Kutch. Only the Aji, the Machhu and the Brahmani are northward flowing rivers. The rivers originating in the Girnar and the Gir namely the Ojhat, the Kamb, the Surekh, the Somal, the Sangwada, the Hirani, the Kpila and the Saraswati flow into the sea. The Saraswati near the Somnath and the Vastu are sacred rivers.

The Bhadar is one of the major rivers of Kathaiwar (Saurashtra) peninsula in Gujarat. It originates near Vaddi (Aniali Village) about 26 km north – west of Jasdan in Rajkot district at an elevation of 261 m above mean sea level. It flows towards South up to Jasdan and turns towards south - west up to Jetpur and

finally changes its direction towards west till its confluence with Arabian Sea at Naviobandar (Porbandar). The total length of this river is 198 km.

2. DESCRIPTION AND ANALYSIS OF BHADAR RIVER BASIN :

The Bhadar receives several tributaries on both the banks. There are 9 major tributaries having lengths more than 25 km out of which 6 tributaries namely Gandali, Chapparwadi, Phopal, Utawali, Moj and Venu are feeding from the right and the remaining 3 tributaries namely Vasavadi, Surwa and Galolio from the left. The drainage system of the river on right bank is more extensive as compared to the left bank.

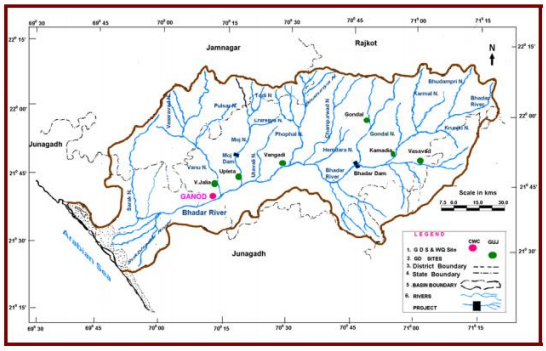
It has a drainage area of 7094 sq.km out of which 706 sq km is in hilly and the rest in plain regions of Saurashtra. The basin lies between geographical co-ordinates of 210 25' and 22010' north latitudes and 690 45' and 710 20' east longitudes. It drains about 1/7th of the area of Saurashtra.

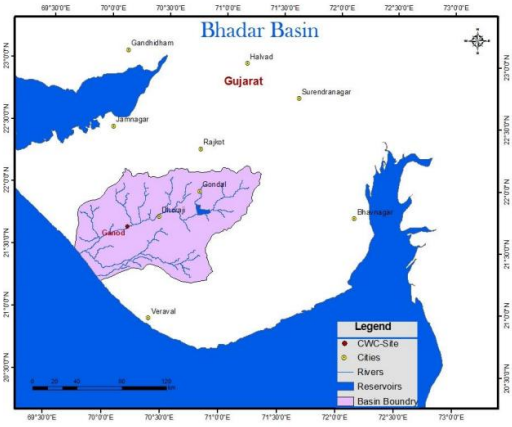
CWC sites in Bhadar basin

Sl.No.	Site Name	River Name / Tributary / Sub-Tributary	Type of Site	Telemetry with type/Non Telemetry	State	District	Location (Degrees)	
							Longitude (E)	Latitude (N)
1	Ganod	Bhader	GDSQ	NT	Gujarat	Rajkot	70.18	21.66

Note: NT- Hydrological Observation sites without telemetry

BHADAR BASIN





Source: CWC site http://www.cwc.nic.in

The average rainfall in Bhadar basin is 625 mm. In winter the temperature vary between 40C and 150C in different Parts of the region. May is the hottest month. Maximum temperature varies between 400 C and 450 C. At present, there are 12 completed structures, either reservoirs or weirs, in Bhadar catchment.

There is only one monitoring station for gauge-discharge and sediment load analysis in this basin, which is near the mouth of river in plains of Rajkot district at Ganod.

The total catchment area of the basin is 7,094 square kilometers (2,739 sq mi) It is impounded by two reservoirs, Bhadar-I reservoir with a capacity of 238 MCM (193,000 acre·ft), and downstream from that,

Bhadar-II reservoir with a capacity of 49 MCM (40,000 acre·ft) Figure 3 shows information about drainage networks i.e. major rivers, streams and large reservoirs.

Name of District	Drainage Area (Km^2)	% of Total
Rajkot	4902.67	69.11
Jamnagar	1047.78	14.77
Amreli	715.78	10.09
Junagadh	427.77	6.03
TOTAL	7094	100

3. SIGNIFICANT FEATURES OF BHADAR RIVER SYSTEM:

Various hydrological and other data analysis of Bhadar basin suggests that temperature variation is found to be 7 to 44 degree C and average annual rainfall is 625 mm. Study carried out by Dayal et al reveals that the basin is of seventh order and is of dendritic pattern. The drainage density of the watershed indicates drainage texture is very coarse.

Major projects on the river are "Bhadar Irrigation Scheme". Gross storage of which is 238 MCM and live storage is of 221 MCM. Sediment transport load was very negligible up to 2005 but found to increase significantly after that with very high in year 2007, the wet year with very high rainfall. Annual flow is found to be varying in a similar trend however it has peak in 2008 which might be due to delayed runoff. The total length of this South West flowing river from its origin to its outfall into the sea is 198 km. For the first 150 km the river flows in Rajkot district and the rest of 48 km in Junagadh district. The river receives tidal influence for a length of about 26 km from mouth in Junagadh district. The river Bhadar receives several tributaries on both the banks.

There are 9 major tributaries having a length more than 25 km out of which 6 tributaries namely Gondali, Chapparwadi, Phopal, Utawali, Moj and Venu are feeding from right and the remaining 3 tributaries namely Vasavadi, Surwa and Galolia from left. The drainage system on the right bank of river Bhadar is more extensive as compared to the left bank. Gondali, Chapperwadi, Phopal and Venu, these 4 important right bank tributaries together account for nearly 35% of total catchment area of Bhadar. Venu is having 953 km^2, Vasavadi-583 km^2, Gondali-513 km^2 and Others are having 5045 km2 catchment area. Venu, which is the principal tributary of Bhadar also rises in Jamnagar district in hilly range and drains Jamnagar and Rajkot districts. Phopal, another tributary rises at high level range about 5 km north of the town Lodhika. The catchment area, length and elevation of sources of important tributaries are indicated below:

SUB-BASIN	WATERSHED CODE	NAME OF STREAM	TOPOSHEET NO	AREA (KM^2)
BHADAR AND OTHER WEST FLOWING RIVERS	BHDR001	UPPER BHADER	41N,O,J,K	1036
	BHDR002	UPPER BHADER	41J,K,O	1311
	BHDR003	MIDDLE BHADER	41J,K	1257
	BHDR004	UPPER OJAT	41K	878
	BHDR005	MIDDLE OJAT	41K	585
	BHDR006	UBEN NADI	41K	773
	BHDR007	MIDDLE BHADER	41J,K	1003
	BHDR008	MIDDLE BHADER	41J,K	557
	BHDR009	SONAT NADI	41K,L	867
	BHDR010	HAMA RIVER	41K,L	1172
	BHDR011	MTEGAL NADI	41K,L	534
	BHDR012	NOLI	41K	345
	BHDR013	LOWER OJAT	41K,G	1478
	BHDR014	LOWER BHADER	41K,G	1150
	BHDR015	LOWER BHADER	41F,G,J,K	1008
	BHDR016	LOWER BHADER	41F,G,J,K	910
	BHDR017	DRAIN	41G	868
	BHDR018	VARTU NADI	41F,G	1122
	BHDR019	SANI NADI	41F,G	660
	BHDR020	SINDHON NADI	41F,G	447
SHETRUNJI AND OTHER EAST FLOWING RIVERS	STRJ001	PANIYA SALALI NADI	41K,O	701
	STRJ002	PANIYA SALAI NADI	41O,K	365
	STRJ003	VADI NADI, SHETRUNJI RIVER	41O	1178
	STRJ004	RAWAL NADI	41K,L,O,P	1247
	STRJ005	RUPEN NADI	41K,L	588
	STRJ006	RAIDI NADI	41O,P	516
	STRJ007	PHARTAQRVADI NADI	41O,P	877
	STRJ008	SHETRUNJI RIVER	41O	1110
	STRJ009	KALU BHAR NADI	41O	784
	STRJ010	GHETO	41N,O	732
	STRJ011	UPPER BHADRA RIVER	41N	1004
	STRJ012	MOTOPA CREEK	41O,P	454
	STRJ013	MALON NADI	41O	744
	STRJ014	SHETRUNJI RIVER	41O	1114
	STRJ015	SHETRUNJI RIVER	41C,O	1552
	STRJ016	KALLUDHAR NADI	41C,O	2032
	STRJ017	GHETO NADI	41N,O	1386
	STRJ018	LOWER BHADRA RIVER	41B,N	2157

Table 1: Sub basin of Bhadar and Shetrunji Rivers and sources of important tributaries detail.

Climatic Characteristics:

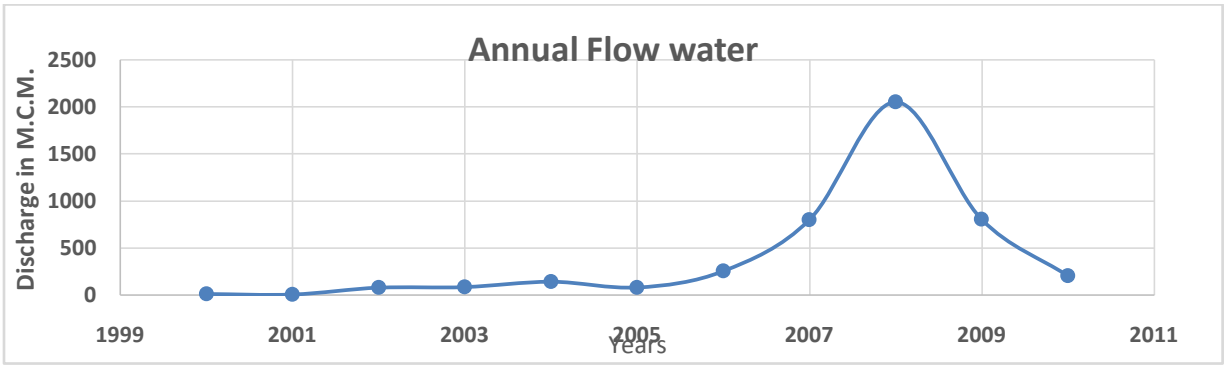
The average rainfall in Bhadar basin is 625 mm. The South West monsoon sets in by the middle of June and withdraws by the first week of October. About 90% of total rainfall is received during July and August. Owing to the topographical characteristics climate is variable. In winter the temperature varies between 40^{o} c &150^{o} c. May is the hottest month. Maximum temperature varies between 40^{0} c and 46^{0} c. rises from Near Vaddi village of Rajkot Dist. of Gujarat at an elevation of 261 m. Length 198 km drainage area 7094 sq km.

Sr. No.	Taluka	2003	2004	2005	2006	Average
1	Dhoraji	646	476	851	1084	764
2	Gondal	676	520	587	729	628
3	Jam Kandorana	732	401	622	896	663
4	Jasdan	678	691	664	886	730
5	Jetpur	548	560	766	840	679
6	Kotada Sangani	593	619	797	716	681
7	Lodhika	536	402	937	894	692
8	Maliya	542	428	591	848	602
9	Morbi	629	642	756	989	754
10	Paddhari	675	371	793	631	618
11	Rajkot	851	693	1072	913	882
12	Tankara	525	329	597	575	507
13	Upleta	820	610	763	1205	850
14	Wankaner	404	543	514	594	514

Table 2 Talukawise average rainfall year 2003 to 2006 (mm)
(Source: Indian Metrological and Revenue Department)

Year	**1999-00**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**
Monsoon	8	3	74	80	138	79	251	795	2032	788	200
Non-Monsoon	0	0	0	0	0	0	0	0	20	12	1
Annual	8	3	74	80	138	79	252	795	2052	800	201

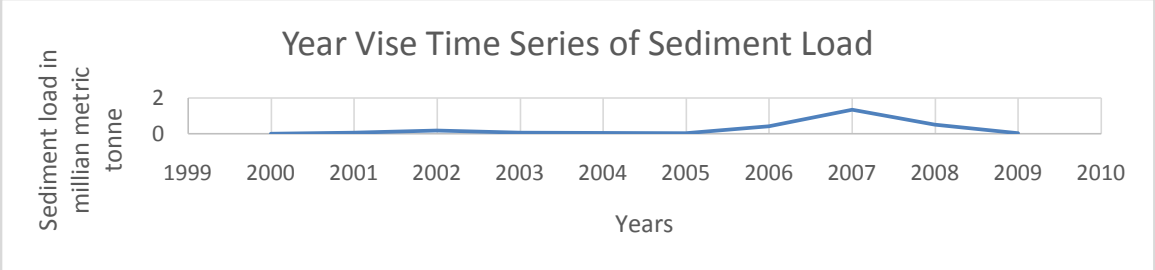
Table 3 Flow of Water in M.C.M. by season for Bhadar river at Ganod



Monthly average flow per unit drainage area in mm for bhadar at ganod												
Months	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flow per Unit Area	5.43	8.92	20.6	18.05	2.52	0.15	0.13	0.03	0	0	0	0.05

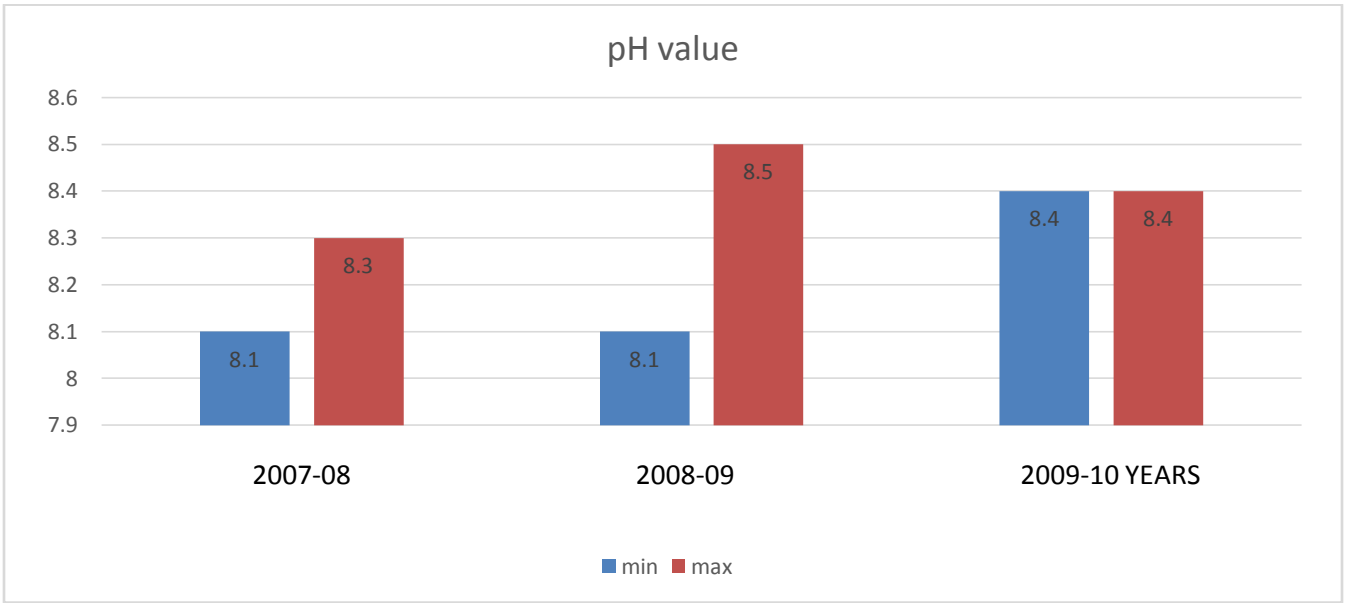
Year	2000	2001	2002	2003	2005	2006	2007	2008	2009
Sediment load in Milian Metric tonne	0.009	0.061	0.187	0.072	0.039	0.434	1.33	0.503	0.049

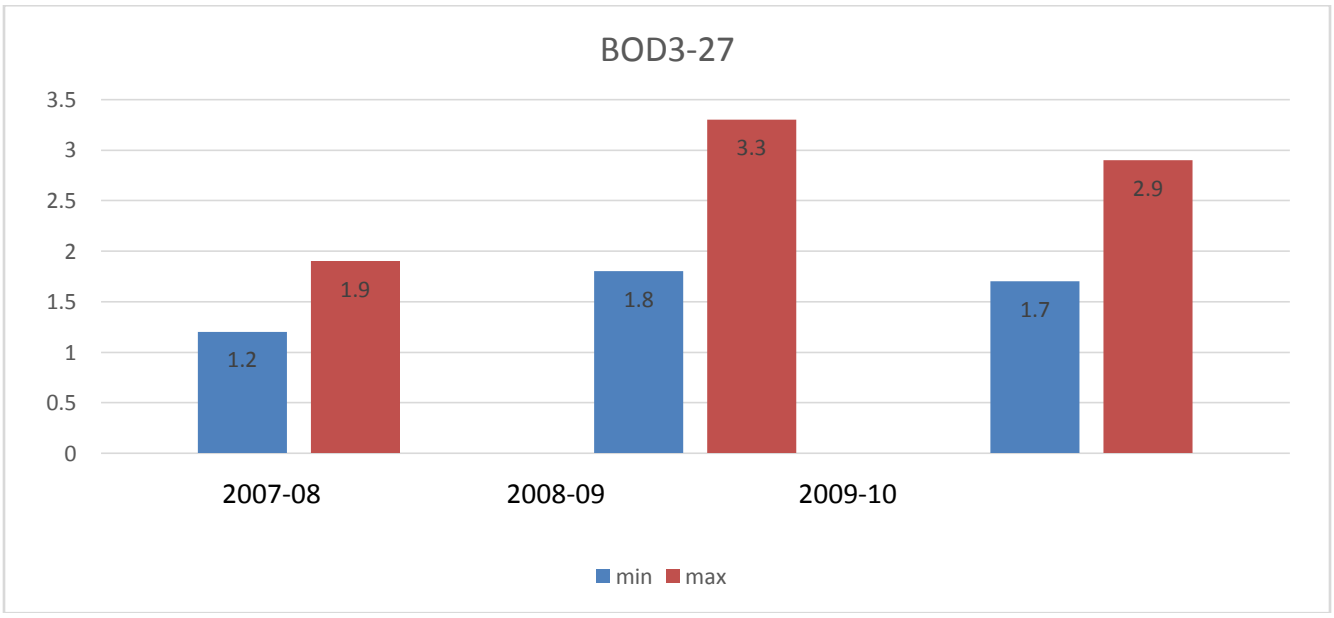
Table4: Time series of Sediment load at Bhadar at Ganod



Parameters		year			Parameters		year		
		2007-08	2008-09	2009-10			2007-08	2008-09	2009-10
Q (Cumecs)	min	0	0	0	Carbonate (CO3)	min	0	0	2
	max	3474	1902	1102		max	5	5	5
Temperature ^{o}C	min	21	23	28	Bicarbonate (HCO3)	min	151	132	132
	max	29	28	28		max	190	317	190
pH_GEN	min	8.1	8.1	8.4	Chloride (CL)	min	64	58	56
	max	8.3	8.5	8.4		max	206	320	182
Potassium (K)	min	0.3	2.5	2.8	Fluoride (F)	min	0.44	0.33	0.87
	max	1	4.6	4.5		max	0.77	0.77	0.92
Sodium (Na)	min	39.7	39.8	38.5	Sulphate (SO4)	min	21.9	29.4	29.2
	max	147	216.7	108.2		max	61.4	80	53.9
Calcium (Ca)	min	45	45	45	Nitrate (NO3-N)	min	0.18	1.08	2.71
	max	74	101	79		max	5.18	7.99	3.38
Magnesium (Mg)	min	9.7	8.8	10.7	Nitrite (NO2-N)	min	0.03	0.03	0.02
	max	11.7	26.2	18.5		max	0.08	0.62	0.7
Aluminium	min	0.02	0.03	0.02	Silica (SiO2)	min	26.8	22.5	18.2
	max	0.07	0.08	0.02		max	44	34.9	28.2
Iron (Fe)	min	0.01	0.9	0.9	DO	min	7.1	6.5	6.7
	max	0.4	1.2	1.1		max	7.8	8.2	7.7
Ammonia (NH3-N)	min	0.02	0.47	0.32	BOD 3-27	min	1.2	1.8	1.7
	max	0.05	0.6	0.44		max	1.9	3.3	2.9
	max	1.9	3.3	2.9					

Table 5 :Major Water Quality Data of Gguage station with Maximum discharge





4. CONCLUSION:

Various hydrological and other data analysis of Bhadar basin suggests that temperature variation is found to be 7 to 44 degree C and average annual rainfall is 625 mm. Study carried out by Dayal et al reveals that the basin is of seventh order and is of dendritic pattern. The drainage density of the watershed indicates drainage texture is very coarse. Major projects on the river are “Bhadar Irrigation Scheme”. Gross storage of which is 238 MCM and live storage is of 221 MCM. Sediment transport load was very negligible up to 2005 but found to increase significantly after that with very high in year 2007, the wet year with very high rainfall. Annual flow is found to be varying in a similar trend however it has peak in 2008 which might be due to delayed runoff.

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