HEALTH ASPECTS OF TRADITIONAL WATER HARVESTING SYSTEMS OF RAJASTHAN

by

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1. INTRODUCTION

India is a signatory to the U.N. resolution on the International Drinking Water Supply and Sanitation Decade (IWSSD) 1980-1990 launched with the laudable objective of providing safe water and sanitation to all the people by the year 1990. In the light of a mid-decade review of progress (Table 1) and constraints experienced, the targets were scaled down to 90 % coverage for urban water supply and 85 % for rural. The Technology Mission on Drinking Water was launched by the Government of India in February 1986 to give an impetus to the on-going rural water supply programme and for improvement in performance and cost effectiveness of the programme to ensure availability of adequate quantity of safe drinking water on sustained basis. As of 1985-86 (base year), out of the 2,27,000 problem villages, 1,54,300 villages (68 %) were without a source of water, 43,600 villages (19 %) had the problem of biological contamination of the sources and 29,100 villages (13 %) had their sources with excessive concentration of inorganic chemical constituents. Despite a quantum leap in investment in this vital sector during the past decade, the achievements fall short of the set targets. There is still a sizable section of the population with no access to adequate quantity of safe potable water. Against this backdrop, this paper presents an overview of some of the traditional methods of water harvesting practised in the country, particularly Rajasthan, their role in the present day context, limitations and prospects with focus on health aspects.

2. OVERVIEW OF TRADITIONAL WATER HARVESTING SYSTEMS (TWHS)

Water harvesting can be interpreted as man's intervention in the natural hydrological cycle to capture, store and use water for his varied needs.

The concept of water harvesting is not new to India. Water harvesting has been a traditional practice in the arid and semi-arid zones. The Khadins, Tankas and Nadis in Rajasthan, Bandharas in Maharashtra, Bundhis in Madhya Pradesh and Uttar Pradesh and Tanks in Andhra Pradesh, Karnataka and Tamil Nadu and Adhas in Bihar are some of the examples of such traditional practices of water harvesting followed for centuries. There are about 5 lakh tanks in India catering to about 4.5 million hactares of irrigated area in addition to serving in most cases human and live-stock drinking purposes. However, some of these tanks have

TABLE 1

WATER SUPPLY COVERAGE

Sector	Population served (in million)							
	1981		1985		1987		1990	
	Population	%	Population	%	Population	%	Projected %	
Urban Water Supply	115.48	72.3	127.27	72.9	145.81	78.25	90	
Rural Water Supply	162.07	30.8	313.56	56.2	NA	-	88	

Source : Domestic and Industrial Water Supply and Wastewater Management, V. Venugopalan and Paritosh Tyagi, National Seminar on New Perspectives in Water Management. Indian National Acadamy of Engineering (1989).

become unserviceable with their storage capacities reduced by as much as 50 % due to rapid siltation incidental to catchment degradation. The introduction of large scale centralised water storage and supply systems through the storage reservoir-canal network has relegated these traditional practices into relative insignificance from public view.

In western Rajasthan, particularly in Barmer district with an annual rainfall of about 200 mm, the quantities of water available from various sources such as surface water and groundwater are not sufficient even for drinking purpose. Over and above the insufficient quantity, the groundwater is moderately to highly saline over a large area. For nearly 76 per cent of the area of the district, the total dissolved salts in ground water range from 1500 to 10,000 ppm. For survival under such conditions, people have been depending on rain water harvesting either for drinking purposes or for agriculture, since time immemorial.

The people of the district, by and large, reside in scattered settlements (dhanis) particularly in the western, north-western and southern parts where sand dunes, interdunal plains and undulating sandy plains are the dominant land forms. In this area, the traditional techniques of rain water harvesting developed by the local people, provide convenient, moderately clean and sweet water for drinking which eliminates the need to scavenge for water in the hot months.

In Jaisalmer district of Rajasthan, water harvesting in Khadins for agriculture has been practised for decades. In the 1950s interest in rain harvesting increased and some lower cost treatments of shaped, compacted earth catchments supply water for both households and livestock. Their performance is good when they are properly maintained.

With the advent of piped water supply, the traditional water harvesting systems have been largely neglected if not totally abandoned. Recently, due to consecutive droughts all surface water resources dried up and the yield from bore wells reduced considerably in most parts of the country. Besides, water table has lowered down and salinity has increased which have once again drawn the attention to the role of water harvesting structures in drinking water supply schemes.

2.1 Brief Description of TWHS

The water harvesting structures may be classified as under :

<u>For Drinking Water Supply</u>

- Tankas, Nadis, Roof water harvesting, Sanitary diggies

For Conjunctive Water Use

- Khadin, Percolation tank, Anicuts/ Check dams, Gully plugging, Sub-surface barriers for artificial recharge of ground water, Abandoned quarries for water harvesting/ development, Contour bunds

Some of the more commonly used systems in Rajasthan are described below.

2.1.1 Tankas

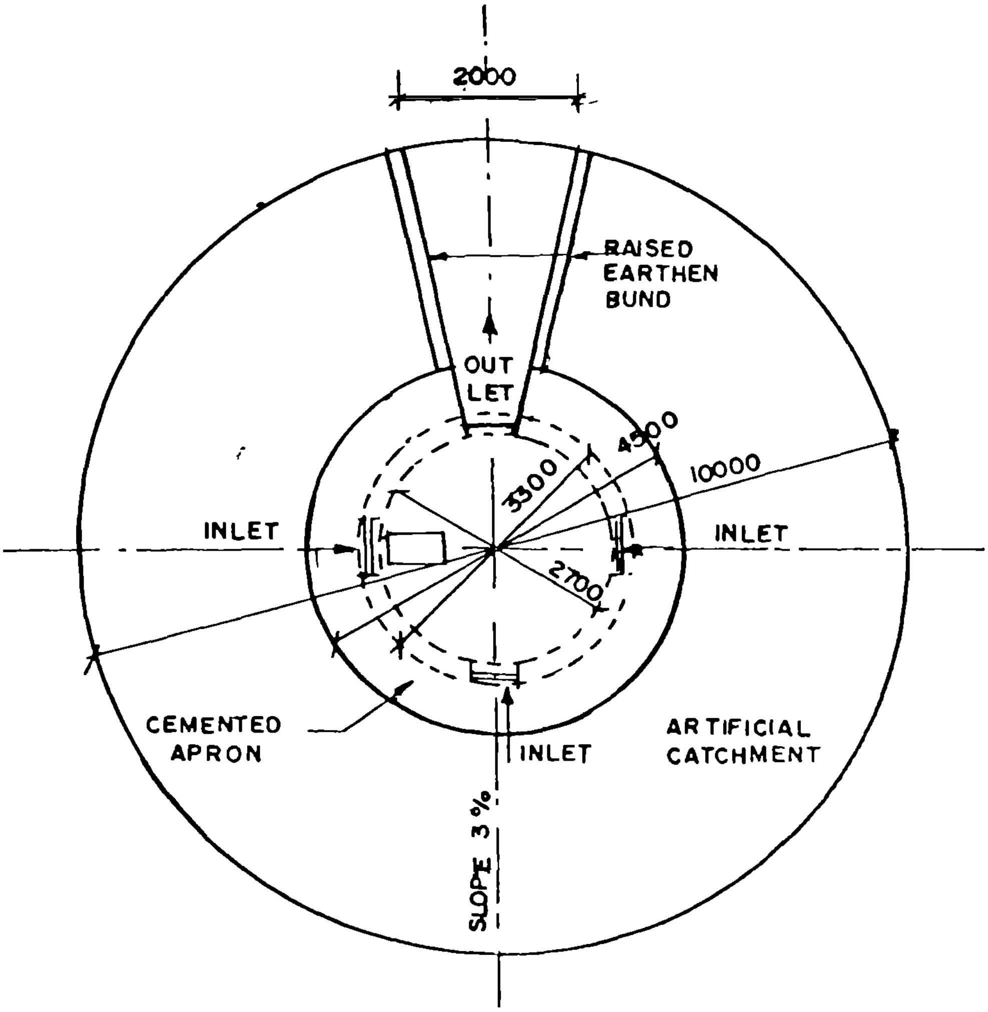
'Tanka' is a local name to a covered underground tank, generally constructed of masonry or concrete for collection and storage of surface run-off (Figs. 1a & 1b). The Tankas are constructed to meet the water supply needs of individual households/ small communities. The history of Marwar reveals that the first known construction of tanka in this region was during the year 1607 A.D. by Raja Sursinghji in village of Vadi Ka Melan. Further, in the Mehrangarh fort at Jodhpur, a tanka was constructed during the regime of Maharaja Udaisinghji in the year 1759 A.D. It was, during the great famine of 1895-96, that the construction of tankas was taken up on a large scale in this region. Rain water harvesting in tanka offers the advantages of private ownership without losing economics of size. Details of improved design of Tanka and method of construction have been reported by Vangani et al (1988).

2.1.2 Nadis

Nadis are small excavated or embanked village ponds, harnessing the meagre precipitation, to mitigate the scarcity of drinking water in the Indian desert (Fig.2). Water from these is available for two months to a year after rain, depending on the catchment characteristics, the amount of rainfall received, its intensity and distribution. The first recorded masonry Nadi was constructed in 1520 A.D. near Jodhpur during the regime of Rao Jodhaji. The traditional Nadis are affected with heavy sedimentation, high evaporative and seepage losses and water pollution. These limit the proper utilisation of water from the Nadis.

2.1.3 Roof Catchment System

For domestic water supplies, the most common type of rain water catchment for individual household use is a roof. Reasonably pure rain water can be collected from house roofs made of tiles, slates (corrugated) galvanised iron, aluminium or asbestos cement sheeting. There are a number of advantages in the use of roofs. First, there is a much reduced chance of contamination than with a ground catchment because it is relatively inaccessible to animals and humans. Second, a roof often provides an inexpensive impervious collector surface



ALL DIMENSIONS IN MM

PLAN

FIG.1a: TANKA FOR A SINGLE FAMILY

(SOURCE: NIDC, 1988)

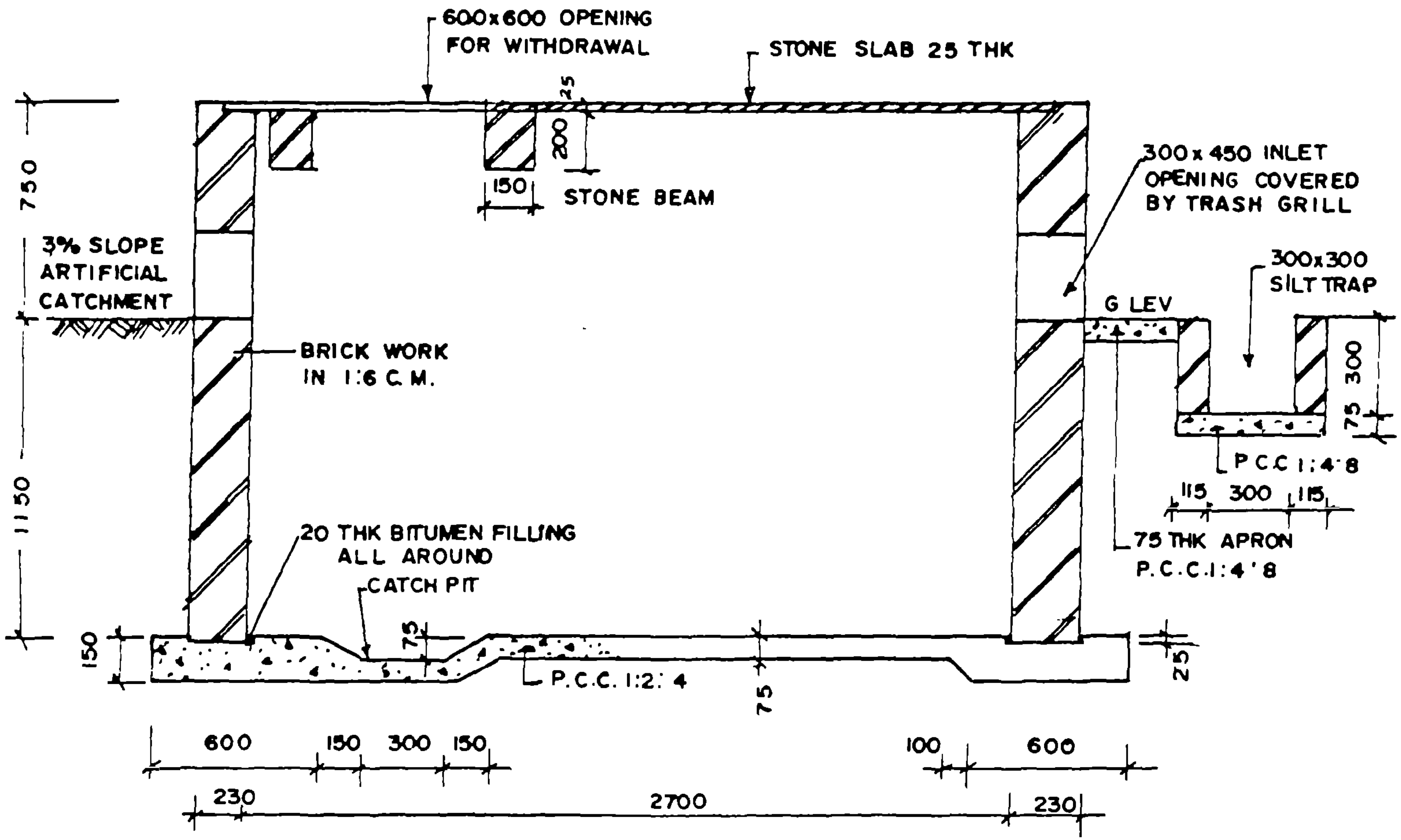


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FIG.1b: TANKA $6m^3$ WITH BRICK WALL

(SOURCE: NIDC, 1988)

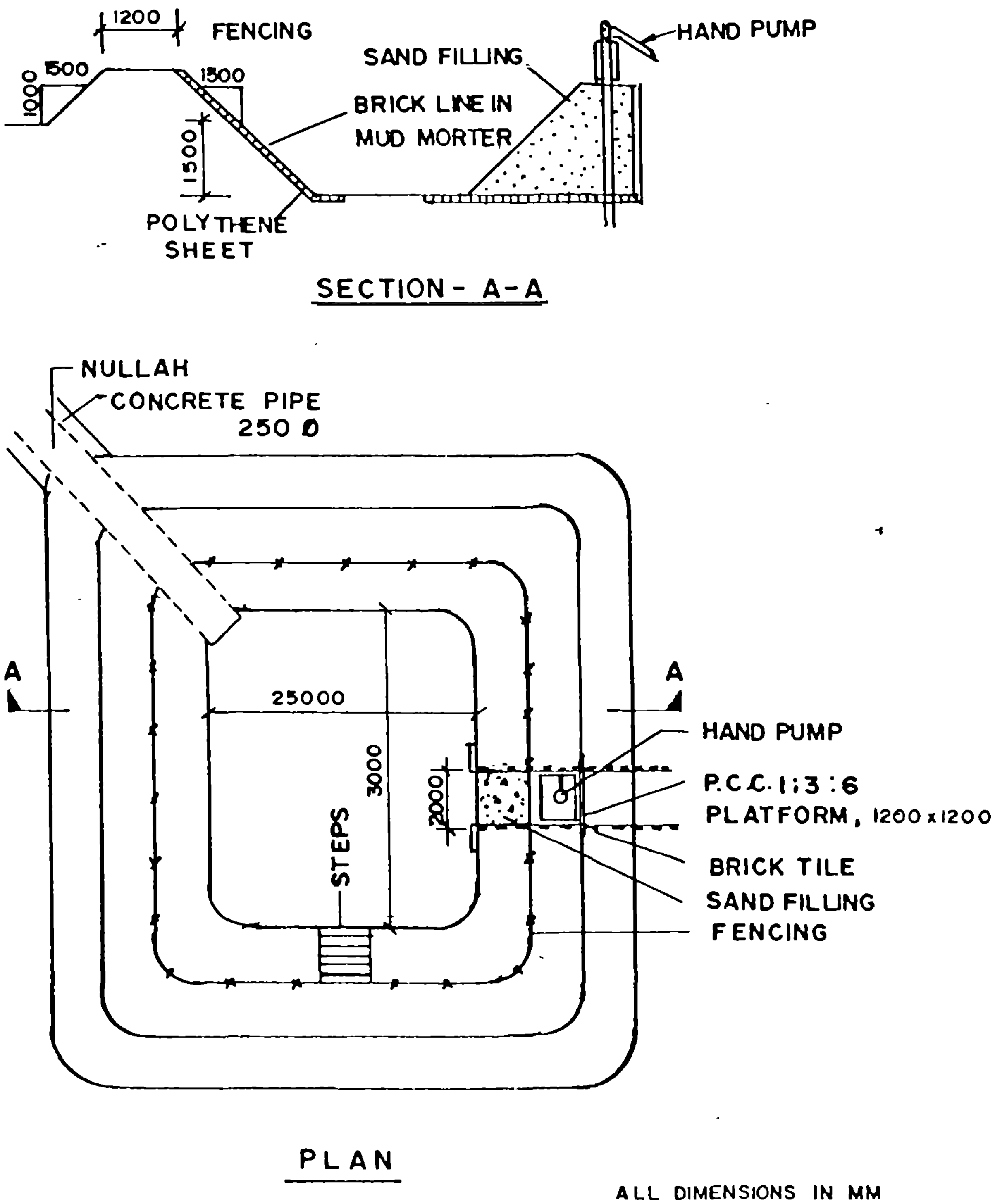


FIG. 2: VILLAGE POND (NADI)

(SOURCE: NIDC, 1988)

without additional cost because it is already in place, and thirdly as it is elevated, a roof catchment permits either above or below storage system.

As shown in Fig. 3, a roof catchment system consists of three basic components, viz. roof which is used as the catchment apron for collecting the rain; gutters and a downpipe for conveying the rain water to the tank once it is collected and a tank for storing the water for future use.

As dust, dead leaves and bird droppings will accumulate on the roof during dry period, it is necessary to arrange the downpipe so that the first flush from each shower can be diverted to waste. To safeguard the quality of the collecting rain water, the roof and guttering should be cleaned regularly. A wire mesh should be placed over the top of the downpipe to prevent it from clogging with washed-off material.

The quantity of rain water that can be collected through roof catchment, will be largely determined by the effective area of the roof and the local annual rainfall. One millimeter of rainfall on one square metre of roof will yield 0.8 litre of water, allowing for evaporation and other losses. To allow for conditions in years that are drier than average and also for seasons of exceptional duration, the roof and storage should have about 50 per cent surplus yield over the basic water requirements.

2.1.4 Khadins

Water harvesting and runoff farming has been an ancient practice in various parts of arid zone of India. 'Khadin' is one such system basically innovated for runoff farming by the Paliwal Brahmin Community in Jaisalmer area in former Jaisalmer State, in 15th century. A Khadin is constructed in a valley of rocky, hilly area or low lying area of stony, gravely waste land. The Khadin bund designed on the basis of rainfall pattern, catchment characteristics, soil type etc. is constructed on the downstream side of the catchment (Fig.4).

In Jaisalmer, the ruler used to encourage people to develop this system on suitable sites, grow and develop agriculture and share the part of it with the ruler, who would remain the owner of it. However, later Paliwal community was either driven out or left the region and for long period, no new Khadins could be made but old Khadins continued to be used. However, their proper management got neglected. Still, there are as many as 500 big and small Khadins in present Jaisalmer district which are still productive with even 40 mm rainfall.

3. WATER QUALITY OF TRADITIONAL SYSTEMS

Notwithstanding the fact that the traditional water harvesting systems have been in use for centuries, information on these systems with respect to their distribution, their efficacy

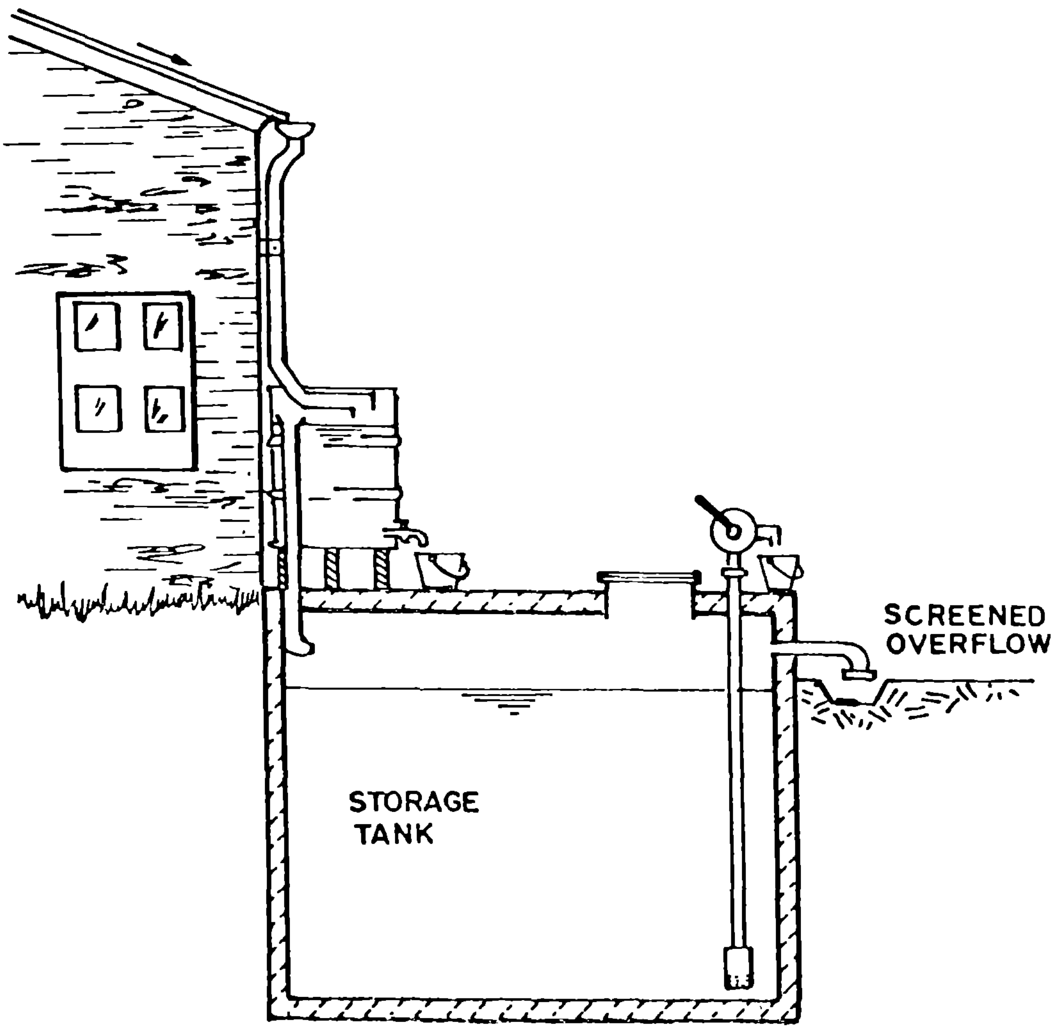
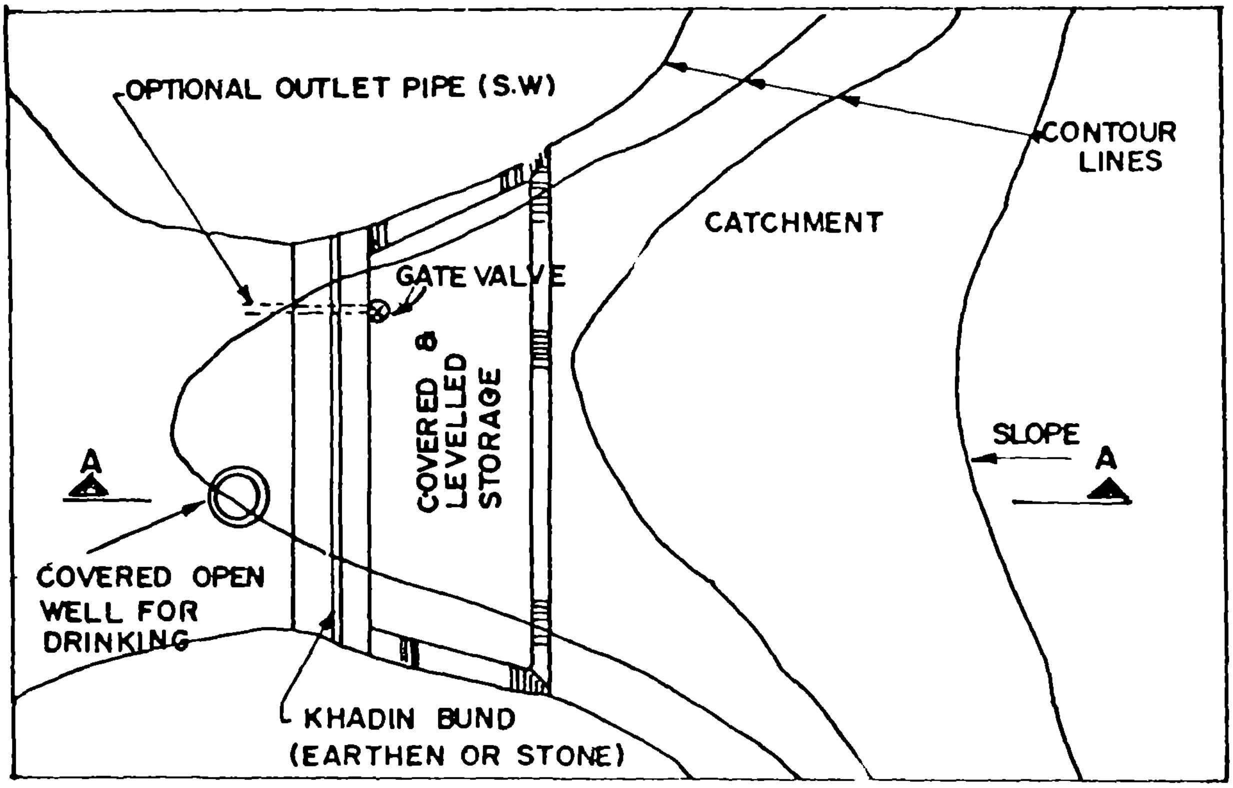


FIG. 3 : ROOF CATCHMENT AND STORAGE OF RAINWATER (WITHDRAWAL BY HANDPUMP)

(SOURCE: I R C, 1981)



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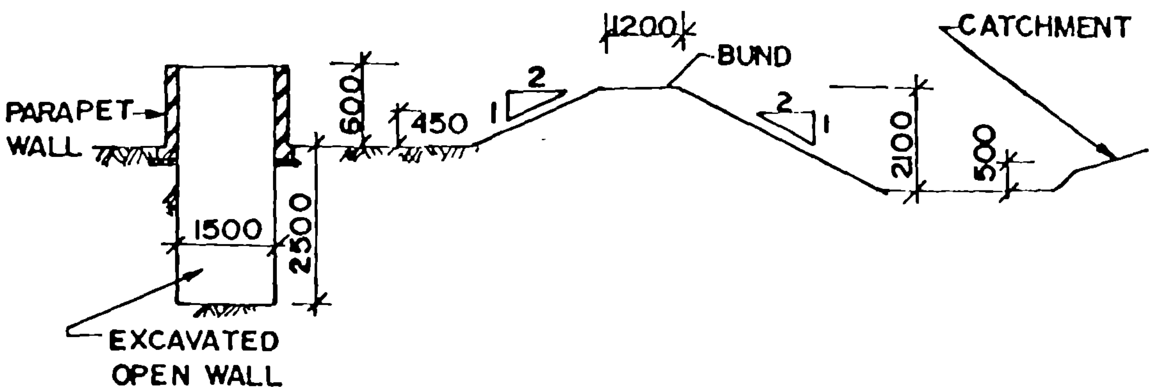

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ALL DIMENSIONS IN MM

FIG.4: KHADIN SYSTEM

(SOURCE: NIDC, 1988)

for the intended uses, the quality of water obtained from these systems and associated health and socio-economic aspects has not been adequately documented.

Under an integrated approach aimed at resolving the problem of drinking water supply, extensive field studies were undertaken by NEERI during April-May, 1988 in four mini-mission districts viz. Barmer (Rajasthan), Nagpur (Maharashtra), Koraput (Orissa) and East Sikkim (Sikkim). Among other constituent activities, water quality assessment and problem identification were undertaken for the first time in a large number of villages. Out of the 853 inhabited villages in Barmer district, 835 are classified as problem villages with 649 having no source, 69 having excess chemical content and 117 having bacteriological/ biological contamination in the water sources. The classification of villages by PHED, Govt. of Rajasthan with respect to water supply is given in Table 2.

From 312 problem villages in the district, water quality from 351 sources like Nadis, Tankas, open wells and bore wells was evaluated. The selection of villages for the study included a fair mix from the different regions in the district and population groups. The villages covered included the problem villages as classified by the state PHED in 1988. The physico-chemical, bacteriological and biological quality of water collected from the traditional sources is presented in Tables 3 through 8.

From the results of the physico-chemical analyses of water samples, it could be seen that many of them had chemical parameters of health significance such as fluorides and nitrates exceeding the desirable limits. In many cases, the total dissolved solids (TDS) concentration, iron and manganese also exceeded the desirable limits, thereby falling under the category of excess chemicals villages.

All the water samples collected from the traditional sources like Tankas and Nadis, showed heavy faecal contamination (Tables 6 & 7). In many villages the Tankas were badly contaminated with floating organic debris, weeds etc. contributed mainly by the ropes and buckets used to draw water. The high chlorine demand of water samples collected from Tankas is a clear indication of high organic matter in the water (Table 9). Many Tankas were also breeding grounds for mosquitoes.

The results of an earlier study by Khanna et al (1984) in Dungarpur and Banswara districts are summarised in Table 10. The samples were collected from the traditional sources comprising mainly step wells.

In general, it is observed that the water quality from the traditional systems studied does not satisfy the drinking water quality standards recommended by CPHEEO, Ministry of Urban Development, Govt. of India (Table 11).

TABLE 2

RAJASTHAN PHED CLASSIFICATION OF VILLAGES
WITH RESPECT TO WATER SUPPLY

Classification	Description
Category 1 : No source village	1. Source inadequate
	2. Source with TDS > 2000 mg/l
	3. Source distance > 1.6 km
	4. Source depth > 15 m
Category 2 : Excess chemicals village	1. TDS 1000-2000 mg/l
	2. Chlorides 500-1000 mg/l
	3. Fluorides 1.5-3 mg/l
Category 3 : Health problem village	1. Prevalence of fluorosis and guinea worm

TABLE 3

PHYSICO-CHEMICAL QUALITY OF TRADITIONAL WATER SYSTEMS

Sr. No.	Name of Tehsil	Name of Village	Source	Temp. oC	pH	Conductivity uS/cm	Dissolved solids	MO.Alkalinity as CaCO3	Total Hardness as CaCO3	Calcium as Ca++	Magnesium as Mg++	Iron as Fe (II)& (III)	Manganese as Mn (II)& (IV)	Sodium as Na+	Potassium as K+	Chlorides as Cl-	Sulphates as SO4--	Nitrates as NO3-	Fluorides as F-
1	PACHPADRA	GANGAWAS	BHERI	30	8.1	720	510	332	230	52	24	4.54	0.36	80	28	30	100	12	0.58
2	PACHPADRA	MANDLI	NADI	28	7.5	1600	840	164	190	60	10	4.09	0.42	170	128	250	150	106	1.30
3	PACHPADRA	KOORI	BHERI	28	8.1	2050	1300	316	400	96	39	0.61	0.18	320	37	360	100	14	0.26
4	PACHPADRA	SAJIYALI PADAMSINGH II	TANKA	32	8.1	2300	1230	180	330	76	34	-	-	400	9	470	110	9	0.65
5	BARMER	MALWA CHARNAN	TANKA	28	8.3	2350	1220	140	310	72	32	0.13	0.01	212	10	490	115	11	0.72
6	PACHPADRA	PATODI	BHERI	28	8.1	6200	3400	148	1050	196	136	0.27	0.01	710	148	1400	430	158	0.82
7	PACHPADRA	PATODI	BHERI	-	7.9	19000	9100	356	2170	276	360	0.19	0.03	710	352	4550	1125	311	2.00
8	PACHPADRA	PATODI	BHERI	-	8.0	15000	8010	304	2080	356	289	0.11	0.07	2180	450	3700	1600	283	0.96
9	BARMER	KHARDA BHARATSINGH	Tanka	32	8.1	540	285	140	188	53	14	0.49	0.15	26	10	40	50	20	0.46
10	CHOHTAN	BHILON KA TALA	Nadi	30.5	8.4	8600	4665	596	350	37	63	0.13	0.06	1740	90	1850	450	65	10.40
11	CHOHTAN	JESAR	Tanka	32	7.9	13600	7115	292	1240	256	146	0.04	0.02	2020	50	3600	313	85	0.52
12	CHOHTAN	KELNOR	Tanka (BSF)	29	8.1	3400	2010	296	660	126	84	0.18	0.02	440	60	750	250	229	2.60
13	BARMER	CHAK DHOLKA	TANKA	-	8.4	3900	2145	292	420	91	47	0.71	0.08	720	13	785	250	8	1.7
14	BARMER	CHAK LANI	TANKA	-	8.3	2800	1530	300	272	69	24	0.32	0.03	525	13	500	110	7	1.2
15	SHEO	GOONGA	TANKA	30	7.9	3550	1935	308	430	99	44	0.00	0.01	615	13	690	215	0	1.1
16	SHEO	CHAK NEGARDA	TANKA	30	8.4	2700	1570	404	460	69	70	0.00	0.03	485	11	470	155	36	2.7
17	SHEO	HARWA	TANKA	24	7.8	5000	2795	272	540	99	71	0.68	0.06	855	21	1070	360	11	1.4
18	SHEO	MOOGERIYA	TANKA	33	7.7	3400	1550	400	360	108	22	0.00	0.00	650	10	650	180	20	2.4
19	SHEO	NEGARDA	TANKA	32	8.2	2400	1420	296	436	84	55	0.02	0.00	465	6	420	210	22	2.5
20	SHEO	MEGA KA GAON	TANKA	28	8.0	4100	2275	324	600	125	70	1.42	0.06	715	19	800	330	0	1.1
21	SHEO	GORDIA	BHERI	31	7.9	11100	6050	180	1570	298	201	0.39	0.07	1850	42	1800	260	1088	4.0
22	BARMER	SUWARA	TANKA	-	8.1	6200	3330	308	270	24	51	0.40	0.02	1125	19	1300	330	12	2.7
23	SHEO	MAJHOLI	TANKA	-	8.5	4150	2585	444	380	28	75	0.49	0.04	810	15	750	325	37	0.8
23	BARMER	BABU GULERIYA	TANKA	27	8.7	5000	2770	468	300	40	49	0.28	0.03	985	20	1000	270	12	2.4
25	BARMER	KHARIYA KALAN	TANKA	26	8.2	5700	3250	404	390	60	58	0.00	0.01	985	17	1250	130	67	1.7
26	BARMER	SETRAU	TANKA	31	8.8	4150	2380	444	250	44	34	0.04	0.01	880	17	850	225	15	1.9

TABLE 3 (Contd..)

Sr. No.	Name of Tehsil	Name of Village	Source	Temp. oC	pH	Conductivity uS/cm	Dissolved solids	MO.Alkalinity as CaCO3	Total Hardness as CaCO3	Calcium as Ca++	Magnesium as Mg++	Iron as Fe (II)& (III)	Manganese as Mn (II)& (IV)	Sodium as Na+	Potassium as K+	Chlorides as Cl-	Sulphates as SO4--	Nitrates as NO3-	Fluorides as F-
27	BARMER	BHELON-KA-PAR	TANKA	-	8.5	3350	1900	688	300	48	44	0.30	0.02	685	12	700	131	2	2.0
28	BARMER	AJBA KA-PAR	TANKA	25	8.4	3650	2080	408	270	52	34	0.69	0.03	765	11	650	225	15	2.6
29	BARMER	JALEELA	TANKA	29	9.0	3900	2155	488	230	44	29	0.33	0.03	850	30	700	210	45	1.8
30	BARMER	ABHERA KA PAR	TANKA	30	8.6	4300	2430	460	280	44	31	0.25	0.02	925	15	900	215	86	2.0
31	BARMER	SURALI	TANKA	31	8.3	4100	2310	484	300	64	58	0.22	0.04	890	12	750	225	15	2.0
32	BARMER	SELAU	TANKA	32	8.4	12000	5800	372	930	128	148	0.17	0.03	2070	21	3250	210	58	1.5
33	BARMER	GARDIYA	TANKA (MIX)	31	8.1	2650	1605	432	170	36	19	0.43	0.02	520	17	400	130	30	4.7
34	SHEO	MUNABAO	TANKA	35	8.7	3200	1825	444	200	28	32	0.10	0.01	625	12	550	180	5	2.0
35	BARMER	HINDIYA	TANKA	30	9.1	4600	2450	448	180	24	29	0.76	0.05	865	22	980	240	12	2.0
36	BARMER	SHERE KA TALA	TANKA	33	8.4	4600	2565	560	360	72	44	0.72	0.10	815	24	890	230	32	1.8
37	BARMER	PANDHI KA PYAR	TANKA	31	8.4	4300	2400	504	360	60	51	0.87	0.04	810	13	820	230	5	2.2
38	BARMER	NEELSAR	TANKA	35	8.3	2450	1400	344	200	48	19	0.89	0.02	470	9	440	110	24	1.7
39	SHEO	BANDASAR	TANKA	26	8.3	4200	2440	448	330	56	46	0.12	0.02	800	12	880	230	6	2.1
40	BARMER	PEERON KA PAR	TANKA	31	8.2	3600	1850	408	330	68	39	0.20	0.02	730	10	900	242	4	2.8
41	BARMER	BIDOO SIYANI	TANKA	34	8.6	3850	1905	376	310	52	44	0.11	0.01	745	11	700	262	8	3.0
42	BARMER	ALARA KA PAR	TANKA	32	8.6	3650	1815	388	290	60	34	0.40	0.02	740	16	800	230	10	2.6
43	BARMER	BIRAD KA PAR	TANKA	31	8.5	3650	1835	382	320	60	41	0.55	0.03	735	11	750	240	15	2.9
44	BARMER	GAGNIYA KA PAR	TANKA	32	8.5	3550	1780	376	310	64	36	0.71	0.07	710	13	800	220	11	2.7
45	BARMER	PUDPUDIYA	TANKA	31	8.5	3750	1820	404	300	64	34	0.51	0.03	735	11	750	248	11	3.0
46	BARMER	BHINDE KA PAR	NADI	31	8.3	940	650	268	340	44	56	0.36	0.04	98	15	55	75	87	5.5
47	BARMER	BUKAR	BHERI	29	8.5	1260	790	196	310	32	56	0.68	0.03	200	13	150	115	54	4.6
48	SHEO	DABAR	TANKA	31	9.1	3400	1695	496	250	20	49	1.15	0.02	695	14	600	101	8	2.8
49	BARMER	DABA KA PAR	TANKA	30	8.2	1350	835	160	190	40	22	0.00	0.02	275	12	250	110	10	0.9
50	BARMER	MANDROO KA PAR	TANKA	30	8.5	3750	2160	392	330	60	44	0.34	0.02	740	11	750	325	2	2.9
51	BARMER	ABHE-KA-PAR	BHERI	29	8.1	2150	1210	496	370	92	34	2.98	0.25	370	85	200	215	73	3.0
52	BARMER	ABHE-KA-PAR	TANKA	32	8.7	3800	2200	384	290	44	44	0.28	0.01	710	13	800	238	4	2.6
53	BARMER	SODAT	BHERI	29	8.3	2000	1010	332	420	88	49	0.72	0.08	340	16	250	110	96	1.3
54	BARMER	CHARWA-JHARWA	TANKA	31	7.8	5200	3100	316	580	96	78	0.00	0.51	980	16	850	610	286	4.0
55	SHEO	DETANI	NADI	32	8.7	580	285	96	200	44	22	3.44	0.13	15	9	50	80	8	0.2
56	SHEO	DRABHA	BHERI	29	8.0	1600	900	120	550	144	46	0.83	0.04	140	14	50	110	256	1.5

TABLE 4

VILLAGES IN BARMER DISTRICT SHOWING TOTAL IRON IN EXCESS OF 1 mg/l.

S.No.	Tehsil	Village	Source	Fe (mg/l)
1	Pachpadra	Gangawas	Bheri	4.54
2	Pachpadra	Mandli	Nadi	4.05
3	Sheo	Maga-ka-gaon	Tanka	1.42
4	Barmer	Khiyala	Nadi	1.53
5	Barmer	Banwa	Nadi	2.27
6	Barmer	Salariya	Tanka	10.75
7	Barmer	Pandi-ka-par	Bheri	5.10
8	Sheo	Dabar	Tanka	1.15
9	Barmer	Abhe-ka-par	Bheri	2.98
10	Barmer	Detani	Nadi	3.44

TABLE 5

VILLAGES IN BARMER DISTRICT SHOWING TOTAL MANGANESE IN EXCESS OF 0.5 mg/l

S. No.	Tehsil	Village	Source	Mn. (mg/l)
1	Sheo	Sheo	Bheri	1.05
2	Barmer	Salariya	Tanka	0.81
3	Barmer	Charwa Jharwa	Tanka	0.51

TABLE 6

BACTERIOLOGICAL QUALITY OF TRADITIONAL WATER SOURCES - BARMER DISTRICT

Tehsil	Village	Source	Total coliform MPN/100 ml
Sheo	Munabao	Tanka	TNC
Sheo	Bandsar	Tanka	32800
Barmer	Jaleela	Tanka	TNC
Barmer	Boothiya	Tanka	TNC
Barmer	Biradh ka par	Tanka	TNC
Barmer	Gagniyoka par	Tanka	TNC
Barmer	Pudpudiya	Tanka	13000
Barmer	Mandroop ka par	Tanka	18600
Barmer	Gagriya	Tanka	TNC
Barmer	Sindari charnan	Tanka	TNC
Pachpadra	Ganagawas	Tanka	TNC
Pachpadra	Koori	Tanka	24200
Chohtan	Konara	Tanka	TNC
Chohtan	Konara	Tanka	37800
Chohtan	Kelnore	Tanka	TNC

TNC - Too numerous to count

TABLE 7

COMPARATIVE BACTERIOLOGICAL QUALITY OF WATER SOURCES

Sr. No.	Tehsil	Number of Samples							
		Handpumps		Dug well		Tanka/Nadis		PSPs	
		Total	+ve for coliforms	Total	+ve for coliform	Total	+ve for coliform	Total	+ve for coliform
1	SHEO	3	3	2	1	2	2	8	6
2	BARMER	4	3	14	13	8	8	6	4
3	PACHPADRA	1	1	1	1	2	2	4	4
4	CHOHTAN	4	3	8	8	4	4	2	2
5	SIWANA	-	-	2	2	-	-	-	-
	Total	12	10	27	25	16	16	20	16

Total samples analysed : 75

Total samples positive : 67

Total samples Negative : 8

TABLE 8

PRESENCE OF CYCLOPS IN TRADITIONAL WATER SYSTEMS IN BARMER DISTRICT

Tehsil	Village	Source	Cyclops Count Per Litre
Sheo	Munabao	Tanka	4
Sheo	Detani	Nadi	15
Barmer	Khiyala	Nadi	7
Barmer	Banwa	Nadi	10
Barmer	Bheelon-ka-par	Tanka	1
Barmer	Gardiya	Tanka	11
Barmer	Salariya	Tanka	7
Barmer	Shere-ka-tala	Tanka	2
Barmer	Daba-ka-par	Tanka	4
Barmer	Khinda Bharatsingh	Tanks	7
Barmer	Cheebi	Open Well	1
Barmer	Somesare Naya	Open Well	10
Barmer	Kharda Bharasingh	Open Well	1
Barmer	Pidiyan Ka Tala	Open Well	2

TABLE 9

CHLORINE DEMAND OF WATER SAMPLES FROM TRADITIONAL SOURCES

Tehsil	Village	Source	Chlorine dose appl. mg/l (range)	Chlorine Demand mg/l (range)
Sheo	Arang	Tanka	2.5-15.0	4.3-4.7
Sheo	Arang	Tanka	2.5-15.0	4.3-7.9
Sheo	Chaknegards	Tanka	3.4-20.4	4.0-5.8
Sheo	Harwa	Tanka	3.5-20.4	8.8-11.0
Sheo	Mega ka gaon	Tanka	3.4-20.4	8.2-9.8
Sheo	Gordia	Bheri	3.4-20.4	5.8-7.8
Sheo	Majholi	Tanka	3.4-20.4	5.7-6.1
Sheo	Munabao	Tanka	3.4-20.4	0.5-2.3
Barmer	Suwara	Tanka	3.4-20.4	8.8-15.2
Barmer	Khiyala	Nadi	3.4-20.4	8.4-10.3
Barmer	Setrau	Tanka	3.4-20.4	2.9-3.5
Barmer	Ajba ka par	Tanka	3.4-20.4	0.4-1.6
Pachpadra	Sajiyali Padamsingh I	Tanka	3.4-20.4	3.6-6.7
Chohtan	Bhilon Ka Tala	Nadi	3.4-20.4	2.4-3.0
Chohtan	Kelnor BSF	Tanka	2.5-15.0	2.9-3.2

TABLE 10

WATER QUALITY IN DUNGARPUR, BANSWARA STEPWELLS

Characteristics	Source* 1	2	3	4	5	6	7	8	9	10
TDS, mg/l	741	546	390	819	546	624	585	429	507	585
Total Hardness as $CaCO_3$, mg/l	284	196	191	309	289	314	309	250	265	269
Calcium Hardness, mg/l	73.5	49	34.3	19.6	24.5	24.5	19.6	103	73.5	54
Chlorides, mg/l	115.5	69.3	57.7	150.2	69.3	115.5	81	57.7	69.3	80.8
Fluorides, mg/l	1.2	1.6	1.5	1.8	1.8	0.9	1.6	1.6	2	1.9
Nitrates, mg/l	10	Traces	10	Traces	40	30	20	25	25	15
Sulphates, mg/l	580	190	180	190	170	240	220	220	220	190
Alkalinity, mg/l	420	300	250	450	300	320	380	280	360	320
Turbidity, mg/l	2.2	1.4	0.5	0.4	1.5	1.4	1.2	1.5	1.2	1.4
pH	8.0	8.0	7.5	8.0	7.5	7.5	7.5	8.0	8.0	8.0
Total coliforms/100 ml	56100	12250	37900	11300	8800	7450	38850	26700	28400	12600
Fecal coliforms/100 ml	8350	5650	2600	1200	1050	1070	3050	-	-	10500
Cyclopes count before chlorination/100 ml								276	15	5

* LEGEND : 1) Barod-Vakalawala Kuan (Dungarpur); 2) Barod-Phuteriwala Kaun (Dungarpur); 3) Gharamoraiya-sanitary well (Dungarpur); 4) Khemaru-Pujela well (Dungarpur); 5) Khemaru-Sapat well (Dungarpur); 6) Matugamda-Patiwala Kaun (Dungarpur); 7) Mathugamda-Boharia well (Dungarpur); 8) Sundani (Banswara); 9) Motayam (Banswara); 10) Keranna (Banswara).

TABLE 11

CPHEEO STANDARDS FOR DRINKING WATER

A) Physical and Chemical Standards :

The physical and chemical quality of water should not exceed the limits shown in the table below :

S.No.	Characteristics	*Acceptable	**Cause for rejection
1.	Turbidity (Units on J.T.U. scale)	2.5	10
2.	Colour (Units on platinum cobalt scale)	5.0	25
3.	Taste and Odour	Unobjectionable	Unobjectionable
4.	pH	7.0 to 8.5	6.5 to 9.2
5.	Total dissolved solids (mg/L)	500	1500
6.	Total hardness as $CaCO_3$ (mg/L)	200	600
7.	Chlorides as Cl (mg/L)	200	1000
8.	Sulphates as SO_4 (mg/L)	200	400
9.	Fluorides as F (mg/L)	1.0	1.5
10.	Nitrates as NO_3 (mg/L)	45	45
11.	Calcium as Ca (mg/L)	75	200
12.	Magnesium as Mg (mg/L)	>30	150

If there are 250 mg/L of sulphates, magnesium content can be increased to a maximum of 125 mg/L with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates.

S.No.	Characteristics	*Acceptable	**Cause for rejection
13.	Iron as Fe (mg/L)	0.1	1.0
14.	Manganese as Mn (mg/L)	0.05	0.5
15.	Copper as Cu (mg/L)	0.05	1.5
16.	Zinc as Zn (mg/L)	5.0	15.0
17.	Phenolic compounds as Phenol (mg/L)	0.001	0.002
18.	Anionic detergents as MBAS (mg/L)	0.2	1.0
19.	Mineral Oil (mg/L)	0.01	0.3
	Toxic Materials		
20.	Arsenic as As (mg/L)	0.05	0.05
21.	Cadmium as Cd (mg/L)	0.01	0.01
22.	Chromium as Hexavalent Cr (mg/L)	0.05	0.05
23.	Cyanides as CN (mg/L)	0.05	0.05
24.	Lead as Pb (mg/L)	0.10	0.10
25.	Selenium as Se (mg/L)	0.01	0.01
26.	Mercury as Hg (mg/L)	0.001	0.001
27.	Polynuclear aromatic hydrocarbons (PAH) (ug/L)	0.2	0.2
	Radio Activity		
28.	Gross Alpha activity (pCi/L)	3.0	3.0
29.	Gross Beta activity (pCi/L)	30.0	30.0

Notes :

* 1. The figures indicated under the column "acceptable" are the limits upto which the water is generally acceptable to the consumers.

** 2. Figures in excess of those mentioned under "acceptable" render the water not-acceptable, but still may be tolerated in the absence of alternative and better source but upto the limits indicated under column "cause for rejection" above which the supply will have to be rejected.

3. It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyse the individual radionuclides in order to assess the acceptability or otherwise for public consumption.

B) Bacteriological Standards :

i) Water entering the distribution system :

Coliform count in any sample of 100 ml should be zero. A sample of water entering the distribution system that does not conform to this standard calls for an immediate investigation into both the efficacy of the purification process and the method of sampling.

ii) Water in the distribution system shall satisfy all the three criteria indicated below :

- <u>E. Coli</u> count in 100 ml of any sample should be zero.
- Coliform organisms not more than 10 per 100 ml shall be present in any sample.
- Coliform organisms should not be detectable in 100 ml of any two consecutive samples or more than 50 % of the samples collected for the year.

If coliform organisms are found, resampling should be done. The repeated finding of 1 to 10 coliform organisms in 100 ml or the appearance of higher numbers in any sample should necessitate the investigation and removal of the source of pollution.

iii) Individual or small community supplies :

<u>E. Coli</u> count should be zero in any sample of 100 ml and coliform organisms should not be more than 3 per 100 ml. (If repeated samples show the presence of coliform

organisms, steps should be taken to discover and remove the source of the pollution. If coliforms exceed 23 per 100 ml, the supply should be disinfected.)

C) **Virological Aspects :**

0.5 mg/L of free chlorine residual for one hour is sufficient to inactivate virus, even in water that was originally polluted. This free chlorine residual is to be insisted in all disinfected supplies in areas suspected of endemicity of infectious hepatitis to take care of the safety of the supply from virus point of view which incidentally takes care of safety from the bacteriological point of view as well. For other areas 0.2 mg/L of free chlorine residual for half an hour should be insisted.

4. HEALTH ASPECTS OF TRADITIONAL SYSTEMS

4.1 Water and Disease

Water intended for potable purposes should be free from disease causing organisms, excessive concentration of inorganic and organic substances of health significance and asthetically acceptable.

The provision of safe water supply means quantity as well as quality. Very low per capita consumption levels do not constitute a safe domestic water supply even if the water is free of contamination. Experience has shown that diarrhoeal diseases were primarily reduced because of the availability of water rather than the quality of water. An average daily minimum of water per person for drinking and basic hygiene, is estimated at 30 litres.

WHO has estimated that 80 % of all sickness and disease in the world is attributable to inadequate water or sanitation. This includes the effects of drinking contaminated water, water acting as a breeding ground for carriers of disease and disease caused by lack of washing. The four types of diseases related to water and sanitation are outlined below :

i) **Water-borne Mechanism** : A water-borne disease in one which is transmitted when the pathogen is in water which is drunk by a person who may then become infected. Potentially, water-borne diseases include the classical infections, notably cholera and typhoid, but also a wide range of other diseases such as infectious hepatitis and bacillary dysentery.

ii) **Water-related Insect Vector Mechanism** : Diseases such as malaria, yellow fever, dengue and onchocerciasis for example, are transmitted by insects which breed in water.

iii) **Water-washed Mechanism** : Water-washed diseases could be of three main types. Firstly, there are infections of the intestinal tract such as diarrohoeal diseases. These diseases mainly spread by way of the faecal-oral route and are susceptible to increased level of cleanliness and proper use and disposal of water. The second type of water-washed mechanism includes infection of the body surface such as scabies, conjunctivitis, skin sepsis etc. The third comprises infections carried by insects parasitic on the body surface. Other ectoparasites cause scabies and others can also give rise to asthma. Louse-borne epidemic typhous and relapsing fever could be caused by lack of hygiene due to a deficient water supply.

iv) **Water-based Mechanism** : A water-based mechanism is one in which the pathogen spends a part of its life in an intermediate aquatic host such as a water snail. Guinea worm is essentially spread by a water-based mechanism.

4.2 Health Impact of Water Quality

The studies in Barmer district of Rajasthan revealed that the village folk were consuming waters with a TDS content of 1500-3000 mg/l without any complaint of taste. With TDS concentration in the range 3000-5000 mg/l, the villagers were still using the waters but with complaint of bad taste. However, water with a TDS beyond 5000 mg/l was not consumed by the people but was used for cattle consumption.

Iron and manganese concentration in almost all the samples from the traditional sources was within the permissible limits and did not pose any problem.

As regards fluorides, while mottled enamel was evident in some of the villages, skeletal or crippling fluorosis was not observed in any of the villages covered under the study. However, dental fluorosis amongst the children was prevalent.

Despite the fact that the concentration of nitrate in some of the traditional water systems exceeded the recommended maximum limit of 45 mg/l, there were no reports of the incidence of methaemoglobinaemia among the infants in the district, which may perhaps be due to the absence of artificial feeding. Since the local population use water from both traditional and other sources of water supply, the health status can not necessarily be attributed to the use of traditional sources only.

The morbidity data collected from the primary health centre, Barmer (Table 12) shows that the majority of the water related diseases are prevalent in the district. However, it is pertinent to note that this information covers population drawing water from various sources including traditional ones.

The results presented in Tables 13 and 14 clearly establish the relationship between the water quality in the step wells of Dungarpur and Banswara districts and the prevalence of guinea worm disease.

5. STRATEGIES FOR IMPROVEMENT OF TWHS

The findings of extensive studies carried out in Barmer, Dungarpur, Banswara and Sawai Madhopur districts of Rajasthan have conclusively shown that the traditional water harvesting systems which are used as sources of water supply, because of their very nature, are highly prone to contamination and do not as such meet the quality standards for drinking water. The preventive/ corrective strategies appropriate to water related disease transmission mechanisms are listed in Table 15.

Improved community water supply and sanitation can have wide ranging health, economic, social and environmental impacts on the lives of people as summarised in Fig. 5. Human potential and productivity may be drastically stunted by ill-health. A clear example is infection by the guinea worm, a parasite that is

TABLE 12

WATER BORNE DISEASES IN BARMER DISTRICT DURING YEAR 1986-1987 AS RECORDED IN PHCs.

Diseases	Primary Health Centres							
	BARMER (1987)	SIWANA (1987)	GUDAMALANI (1987)	DHORIMANA (1987)	BAITU (1987)	SINDHARI (1987)	CHOHTAN (1986)	SHEO (1986)
CHOLERA	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
TYPHOID	28	6	3	Nil	61	36	25	26
PARATYPHOID	Nil	-	-	-	-	-	-	-
AMOEBIASIS	1087	135	87	15	162	372	30	136
GASTROENTERITIS	2749	-	377	1064	648	230	500	131
URINARY CALLULUS	-	-	Nil	-	26	2	-	-
POLIOMYELITIS	9	Nil	Nil	6	Nil	Nil	Nil	Nil
GUINEA-WORM	711	Nil	Nil	Nil	Nil	Nil	-	-
VIRAL HEPATITIS	-	-	17	5	Nil	Nil	Nil	38
INFECTIVE HEPATITIS	-	22	-	-	-	-	-	-

TABLE 13

GUINEA WORM INFESTATION DUNGNRPUR DISTRICT

Sr. No.	PHC	No.of Dhanies infected	G.W. Cases upto Jan.1984	No.of Stepwells infected
1.	Sagwara	147	340	247
2.	Simalwara	180	7	44
3.	Bichhiwara	134	23	358
4.	Punjpur	117	70	30
5.	Damdi	154	137	484
	Total	732	577	1163

TABLE 14

GUINEA WORM INFESTATION-BANSWARA DISTRICT

Sr. No.	PHC	No.of Dhanies infected	G.W. Cases upto Jan.1984	No.of Stepwells infected
1.	Partapur	98	37	58
2.	Tilwara	26	1	7
3.	Cheench	43	3	10
4.	Ganora	51	84	50
5.	Chhota Dungara	12	18	1
6.	Kushalgarh	44	2	12
7.	Chhoti Sarwan	79	-	7
8.	Anandpuri	24	56	86
	Total	377	201	231

TABLE 15

PREVENTIVE STRATEGIES APPROPRIATE TO WATER-RELATED DISEASE TRANSMISSION AND THE MECHANISMS

Transmission Mechanism	Preventive Strategy
Water-borne	. Improve water quality . Prevent causal use of other unimproved sources
Water-washed	. Improve water quantity . Improve water accessibility . Improve hygiene
Water-based	. Decrease need for water contact . Control snail populations . Improve quality
Water-related insect vector	. Improve surface water management . Destroy breeding sites of insects . Decrease need to visit breeding sites

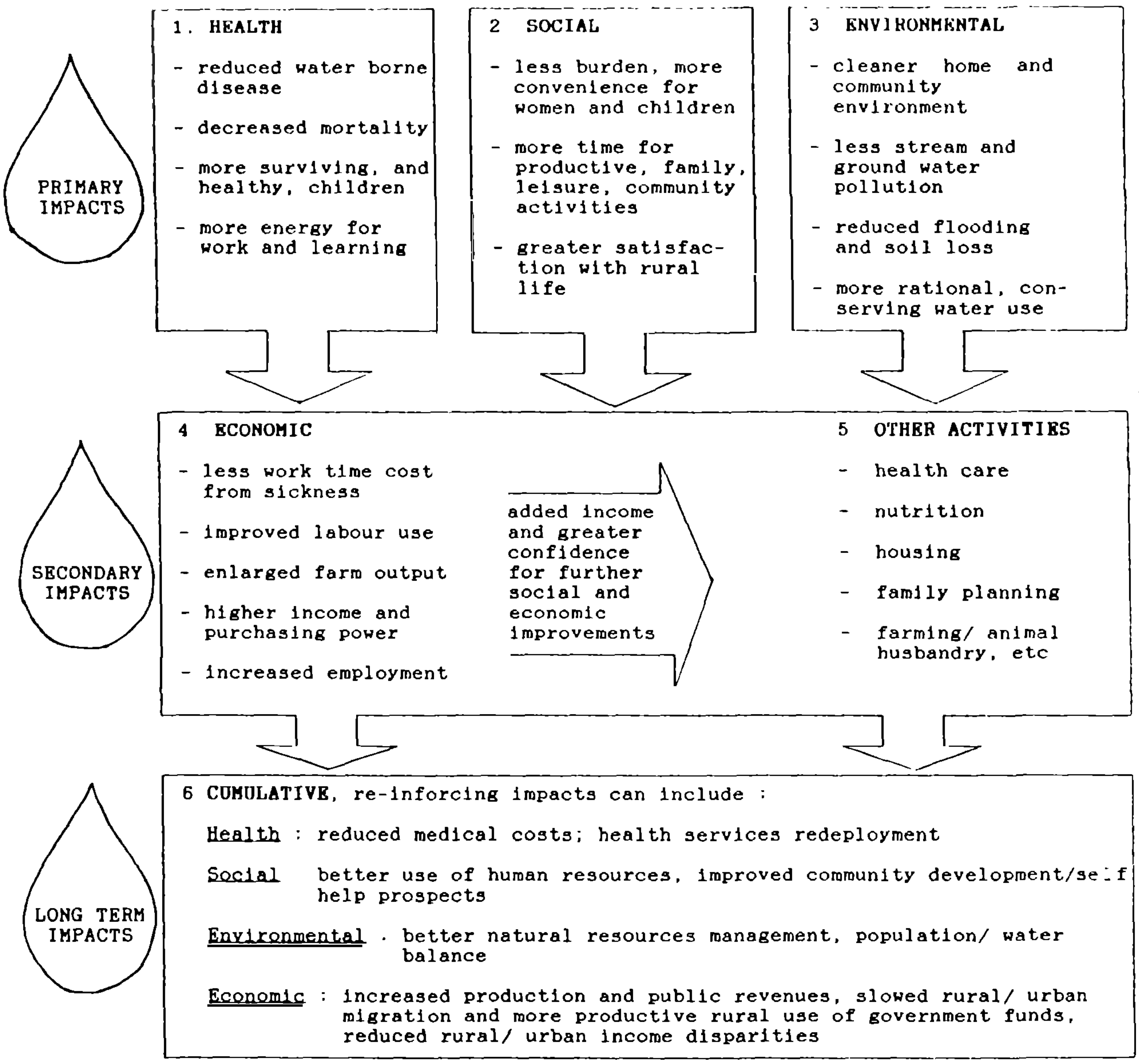

FIG.5 : IMPACTS OF CLEAN WATER AND ADEQUATE SANITATION

transmitted entirely by drinking water. Guinea worm infection, which seldom kills, permanently disables one person in 20, is usually followed by spontaneous recovery even in the absence of any medical treatment. But it causes disability from painful ulcers and abscesses, usually on the feet and legs. In some areas, 30 to 50 per cent of the residents may be incapacitated at one time. Farmers may be laid up for as long as three months right at the time of peak agricultural activity - annual planting and harvesting. The lack of alternative labour sources available to the ailing farmer results in a marked reduction of agricultural output.

Three alternative strategies for guinea worm eradication can be considered.

i) Construction of water sources that can not be contaminated by infected persons

ii) Filtration of water

iii) Disinfection through chemicals

Construction of hand pumps and filtration of water through 100 micron nylon mesh (recommended by WHO, World Health, 1981) is stipulated for instances such as those of Dhanies where coverage with safe water supplies is not ensured. For other areas installation of safe water supplies by conversion of step wells to sanitary wells with adequate disinfection through pot chlorinators is recommended.

Laboratory experiments conducted at the Indian Institute of Technology, Bombay and at NEERI have conclusively established that a free residual chlorine of 0.2 mg/l and a 12 hour contact period at 30^{o}C can effect complete kill of cyclops in water. Field studies conducted in some villages of the district have confirmed the above findings. Thus, effective chlorination of water from traditional and other sources of supplies through pot chlorinators, chlorine tablets/ ampules or a solution of bleaching powder can ensure safety against both bacteriological contamination and guinea worm infestation.

5.1 Support Programme

Some of the associated activities which, when implemented together, would bring about an improvement in the situation are outlined below.

Health Education and Community Participation : No programme aimed at the welfare of the people can achieve any measurable success without the active involvement and participation of the beneficiary community. This together with health and hygiene education could form a formidable tool in ensuring a visible impact on the health and productivity of the people.

Catchment Protection : Prevention is better than cure. Steps taken to protect the catchment area of the traditional water harvesting system would go a long way in minimising the pollution. The catchment area should be properly fenced to keep out cattle and human beings from polluting the area.

Improved Design and Construction : Improvements in the design and construction of catchment area, storage and withdrawal system would not only increase the yield of such systems and their useful life but also reduce the pollution.

Awareness and Motivation : A well organised programme aimed at creating an awareness among the local people regarding the various water harvesting systems with focus on the quality of water from these sources and associated health implications should be the first step in this direction. This is best achieved by NGOS.

6. TRADITIONAL WATER SYSTEMS - A PERSPECTIVE

Arid regions today face more difficult problems than ever before. Vast areas of the country falling in arid and semi-arid regions are prone to frequent droughts. The total area affected by inadequate rainfall is a little over 100 M.Ha which is nearly 30 % of the total area of 328 M.Ha. Successive years of insufficient rainfall greatly affects the availability of water even for drinking purposes. Transport of water for domestic use by trucks on roads and by rail wagons is becoming inevitable in some of the worst affected areas. In this context, traditional water harvesting systems have immediate local value for small scale water development and conservation especially in remote areas with intermittent rainfall. Use of different water harvesting methodologies for supplying drinking water is particularly relevant to areas where source finding is becoming difficult either due to scarcity of the source or due to over exploitation of aquifers. It is also a better alternative in areas having brackish or fuloride or iron-rich ground water.

Water harvesting structures can serve mainly three functions viz. (i) directly supply or supplement drinking water to people (ii) reduce the demand on water supply made by livestock and (iii) recharge aquifers and thereby augment the source and effect better overall management.

Reliability of a rain water harvesting system is largely dependent upon rainfall which could be erratic. Hence, rain water can not be considered as the sole source of water supply and has to be supplemented from other sources for the varied needs. But, for individual household which wants convenience of its own water supply under its own control and for the whole communities when the area lacks surface or ground water, the possibility of rain water collection systems can be attractive.

Traditional water harvesting systems can have important environmental impacts, particularly if linked with wider conservation of water and land resources. Positive consequences include :

- low-cost systems such as Khadins built for water supply purposes can also help prevent soil degradation and watershed loss. Coupled with community reforestation, soil conservation and environmental education, such dams can contribute to overcoming deforestation, over-use of the land, and natural erosion.

- better management of water resources can help reduce waste of arable land, water depletion, soil erosion, desertification, over-use of the land, and natural erosion.

6.1 Suggestions for Action

* Most of the traditional water harvesting systems have been community based or individually owned and, therefore, reliable information regarding their number, types, geographic distribution, relative merits and demerits, water quality, construction materials and cost as well as problems in their upkeep and maintenance is by and large lacking. To fill this gap, a well organised inventory of such systems at state and national level is a felt need. Such an inventory will provide a basis for further research on and development of traditional systems with focus on improved designs, cost-effective construction materials and practices.

* As part of ongoing rural development programmes, rehabilitation of existing systems and construction of new ones may be promoted on need based considerations in areas severely affected by recurrent drought and water scarcity.

* The financing of such works could be through government grants or subsidy depending upon the economic status of the beneficiary. As for their continued use and maintenance, an appropriate mechanism involving voluntary agencies with active participation by the beneficiary, physically and financially,should be evolved.

* Community awareness and education regarding water supply, sanitation and personal hygiene should form an integral part of such development programme for maximizing the health and economic benefits from the traditional water systems.

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BIBLIOGRAPHY

1. Integrated Approach to Water Technology Mission for Barmer District, Interim Report, NEERI, 1988

2. Khanna, P. (1984), "Pre-investment Studies in Rural Water Supply, Sanitation and Health Education in Rajasthan", Development Corporation Office (SIDA), Environmental Science and Engineering Group, IIT, Bombay

3. National Drinking Water Mission Seminar on "Water Harvesting Systems and Their Management", Bangalore, Vol I and II. Dec. 22-24, 1988.

4. International Reference Centre (IRC) for Community Water Supply and Sanitation," Small Commmunity Water Supplies", Technical Paper Series, No.18, August 1981

5. Inpact of Community Water Supply and Sanitation Programmes in Developing Countries, Case History No.6, International Water Supply and Sanitation Decade, UNDP, 1981

6. More Water for Arid Lands - Promissiong Technologies and Research Opportunities, National Academy of Sciences, Washington D.C., 1974

7. Water for the Future - Theme Paper, Water Resources Day 1990, Central Water Commission, Publication No. 67/90

8. Vangani, N.S.; Sharma, K.D.; and Chattarji, P.C., Tanka - A Reliable System of Rain Water Harvesting in the Indian Desert, CAZRI, Publication No.33, January 1988

9. WHO, 1984, 'World Health', p 29