Multi-District Assessment of Water Safety (M-DAWS)

WASMO

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Background

Drinking water has been accorded the highest priority in the National Water Policy of India. Unsafe drinking water has serious health hazards, ranging from physical deformity to life threatening diseases. As per the World Health Organisation (WHO) estimates, diarrhoeal disease is responsible for the deaths of 1.8 million people every year, and an estimate of 88% of that burden is attributed to unsafe water supply, sanitation and hygiene. One of the most serious threats to public health is due to feacal contamination of water supplies. Together with poor sanitation and personal hygiene, feacal contaminated water is a major cause of diarrhoeal disease. For the state of Gujarat, where water shortage constitutes a huge problem, ensuring adequate and safe drinking water to its citizens becomes a huge challenge.

In this context, Multi-District Assessment of Water Safety (M-DAWS) programme has been undertaken by WASMO with financial and technical support of UNICEF, Gujarat to survey and assess the condition of drinking water quality in the state.

Introduction to M-DAWS Programme

M-DAWS programme draws its methodology by referring to the Joint Monitoring Programme planned by WHO and UNICEF in order to assess the safety levels of the water consumed by rural communities and bring about a decline in their susceptibility to water borne diseases. Water quality monitoring ensures safe water supply, and assessing the quality of water consumed by communities still remain a tough challenge as water is availed from various sources in the villages.

Water quality issues can be result of chemical contamination, but microbial contamination of drinking water remains the pre dominant national cause of concern as it has been found that 80% diseases emerge from water and poor sanitation. Rapid assessments of water quality provide useful baseline information regarding water safety. Analysing the link of water quality with sanitary risk becomes important for assessing water quality situation as well as planning for the future.

M-DAWS Methodology

Methodology adopted for M-DAWS implementation is shared in the following section:

The methodology for carrying out M-DAWS / RADWQ (Rapid Assessment of Drinking Water Quality) pilot project is detailed in the handbook, *Rapid assessment of drinking-water quality: a handbook for implementation* (Howard et al., 2003). In essence, the method involves selecting representative sampling points using a statistically-based survey; analysing the water quality for a suite of parameters; carrying out sanitary inspections at the selected sampling points; analysing the data and its relation to historical data; and making conclusions and recommendations.

The survey design selected for the M-DAWS/ RADWQ uses a cluster sampling approach to identify the number, type and location of water supplies to be included in the assessment. Cluster sampling means that the water supplies selected for inclusion in the assessment are geographically close to one another (in "clusters"), but are representative of all water-supply technologies. This approach was selected for RADWQ as it is used in other international surveys on water, sanitation and health (such as MICS) that contribute to the UNICEF/WHO JMP. In addition, cluster sampling improves the efficiency of the assessment by making access to the water supplies easier and by reducing costs.

The key element of the survey design is to ensure that the selection of the water supplies to be included reflects their importance; therefore only improved technologies supplying more than 5% of the population are included. The basic sampling unit is the water supply, rather than the households that use them. The rapid assessments are primarily designed to assess the quality and sanitary condition of the water supplies and hence the risk to water safety. A limited analysis of water stored in households, matched to water sources, is included in the assessment.

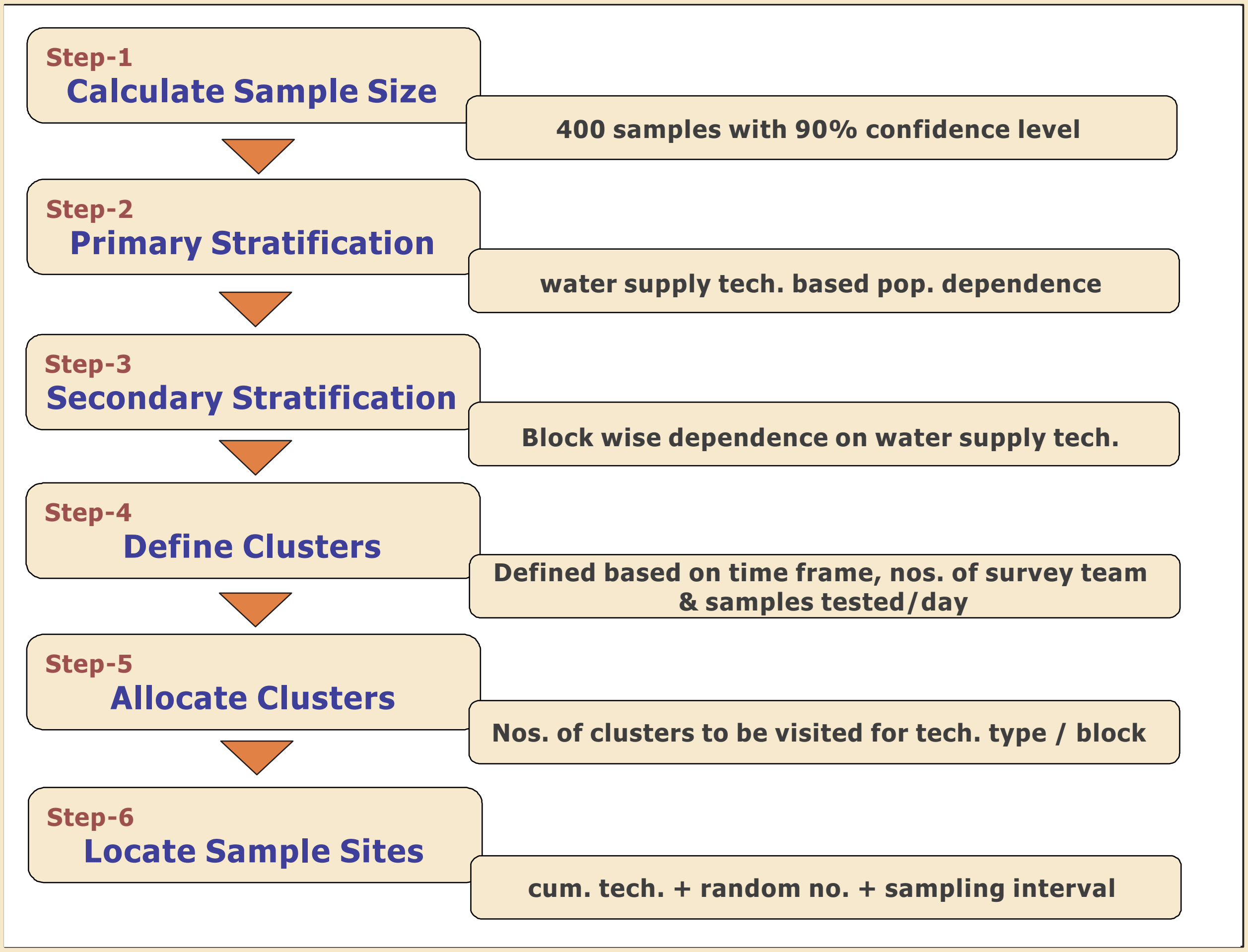
The number of water samples to be taken was calculated using: $n = \frac{4P(1-P)D}{e^2}$

where,

- n = required number of samples (i.e. households) = 400
- *P* = assumed proportion of households with interventions exceeding the target established (0.5)
- *D* = Design effect which reduces the risk of homogeneity associated with a cluster sample estimating as 4 for households
- e = acceptable precision usually +/-0.05, here +/-0.1

Statistical Methodology

Statistical methodology adopted for carrying out M-DAWS study is depicted in the following flow-chart:



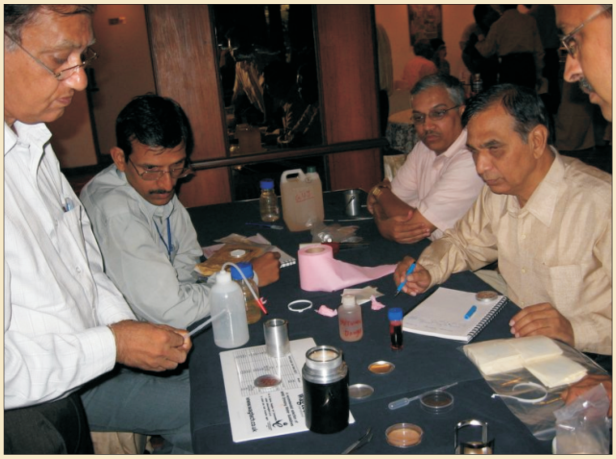
Field Methodology

An elaborate field implementation method has been applied for carrying out M-DAWS programme. A standard procedure adopted for all the districts where M-DAWS have been taken up is pre-implementation workshop wherein all stake-holders at field level are given an orientation about the programme.

It is followed by intensive field implementation which includes sample testing at field through field testing kit, collecting samples for district laboratory testing, data entry and analysis. Based on the field data analysis, a tabulation of chemical and bacteriological parameters is done. Field results are then linked with problem identification and then district level correction action based on technology types is suggested.

Field Implementation steps

- ⇨ M-DAWS training at Bhopal
- ⇨ M-DAWS pilot project – Vadodara District
- ⇨ M-DAWS scale-up project in 7 UNICEF focus districts with following field implementation steps:
  1. Pre-implementation workshop for each district
  2. Field implementation through field team and field testing kits
  3. Analysis of field results
  4. Post-implementation workshop for sharing of findings
- ⇨ Documentation of M-DAWS implementation



M-DAWS Analysis

Data analysis is one of the most important parts of the project, because it is the principle mechanism by which raw data are transferred into usable information for project managers, communities and other decision-makers.

All water-quality and sanitary inspection results were stored in the SanMan database (for Vadodara district only), and later exported to Excel for analysis. An analysis included compliance for microbial, physical and chemical parameters by clusters and supply technology, and for compliance to WHO guideline values and national standards. Household samples were also analysed for microbiological [Thermo Tolerant Coli form (TTC), Feacal Streptococci (FS) / Feacal Count (FC), residual chlorine] and chemical parameters (Nitrate, Fluoride, Salinity, pH), with a focus on how drinking-water quality deteriorated between the distribution system and household taps.

In line with the *WHO guidelines for drinking-water quality* (WHO, 2004), all samples were assessed for sanitary risks by inspections that used a standard set of questionnaires developed for the M-DAWS/ RADWQ project, tabulated as follows:

Technology - wise Sanitary Surveillance Parameters

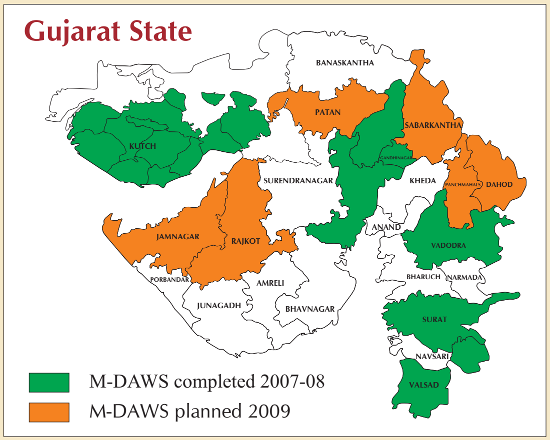
Sr. No.	RWSS	IWSS	Hand-pump	Open well
1.	Toilet within 10 m	Toilet within 10 m	Toilet within 10 m	Toilet within 10 m
2.	Free animal access	Free animal access	Free access to animals	nearest toilet located at level higher than well
3.	Loose housing of tap stands	Broken platform <1.85 m	Broken platform <1.85 m	any source of pollution within 10 m of open well
4.	Wastewater collected in 2 m	Tap stand not firmly fitted	Wastewater collected on platform	water accumulated within 2 m of open well
5.	Open pipeline within 5 m	Open pipeline within 5 m	No waste water gutter or choked	wastewater gutter broken or blocked - water logging
6.	Missing taps	Missing taps from tap stand	Ponding of water within 3 m	open well parapet < 1m / absent
7.	Other sources of pollution within 10 m	Other sources of pollution within 10 m	Other sources of pollution < 10m	cement platform < 1m in periphery of open well
8.	Bathing/washing on platform	Bathing/washing on platform	Bathing or washing on platform	open well walls inadequately sealed upto 3 m below ground level
9.	leakage in pipes within 50 m	leakage in pipes within 50 m	Missing/ corroded pump cover	peripheral cement platform broken - contamination
10.	Leaking taps	Leaking taps	Loose junction of HP with apron	rope & water container not properly kept
11.	Leaks in collection sump	Leaks in collection sump		
12.	Open cover of collection sumps			

The physical parameters including colour, odour and taste were based on individual observation. Inspection of turbidity was carried out with help of Field testing kit.

M-DAWS field implementation

WASMO has implemented M-DAWS programme with financial and technical support of UNICEF, Gandhinagar. It has been implemented in 8 districts upto December 2008.

During year 2009, it is planned to take up M-DAWS implementation in 7 districts as shown in the adjoining map.



M-DAWS time-line

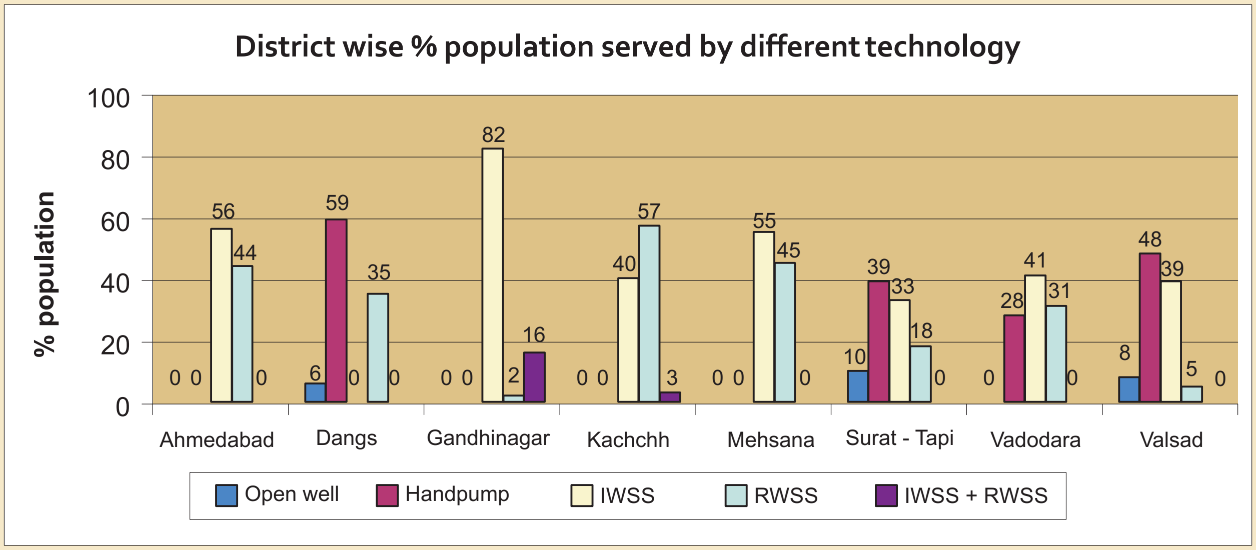
A tabulated year-wise M-DAWS programme carried out in Gujarat is as follows:

Phase - Year	Activities carried out
Phase-I Mar'07 – Dec'07	• Training of M-DAWS programme at Bhopal • Pilot implementation of M-DAWS in Vadodara district (with wagtech kit) • M-DAWS implementation* in Valsad District (Unicef's focus district through FTK) • Hands-on training on M-DAWS to WQ in charge of all districts
Phase-II Mar'08 - Dec'08	• Implementation of M-DAWS through WASMO's Field Testing Kit in Mehsana, Ahmedabad, Surat, Gandhinagar, Kachchh & Dangs districts • High profile workshop on sharing of M-DAWS findings of Valsad, Vadodara and Mehsana districts • Post-implementation workshop for Gandhinagar, Kachchh, Valsad, Vadodara and Mehsana for field teams • District level post-implementation workshop at Valsad district
Phase-III March – Dec'09 (Planned)	• Implementation of M-DAWS in Rajkot district • Implementation of M-DAWS in Dahod, Panchmahal, Patan, Banaskantha, Sabarkantha and Jamnagar districts • Planning for documentation of M-DAWS analysis for 9 focus districts where M-DAWS was implemented in year 2008. • Planning for carrying out workshop on remedial measures based on M-DAWS study carried out: • 5 individual district level workshops for remedial measures (Kachchh, Vadodara, Surat, Mehsana, Rajkot) & 2 combined two-district remedial measures workshop (Ahmedabad-Gandhinagar & Valsad-Dangs)

* M-DAWS implementation includes – pre-implementation workshop and field implementation.

This report is based on analysis of M-DAWS carried out in 8 districts of Gujarat (Vadodara, Valsad, Mehsana, Gandhinagar, Kachchh, Surat, Ahmedabad and Dangs) during years 2007 and 2008. *Refer annexure for Vadodara district report and district-wise details of geography & demography, physical & physiology, geology & geohydrology along with map.*

Major water supply technologies in Gujarat are Individual Water Supply Scheme (IWSS), Regional Water Supply Scheme (RWSS), IWSS + RWSS, open well and hand pumps. The district wise % population served by different water supply technologies is as follows:



M-DAWS findings

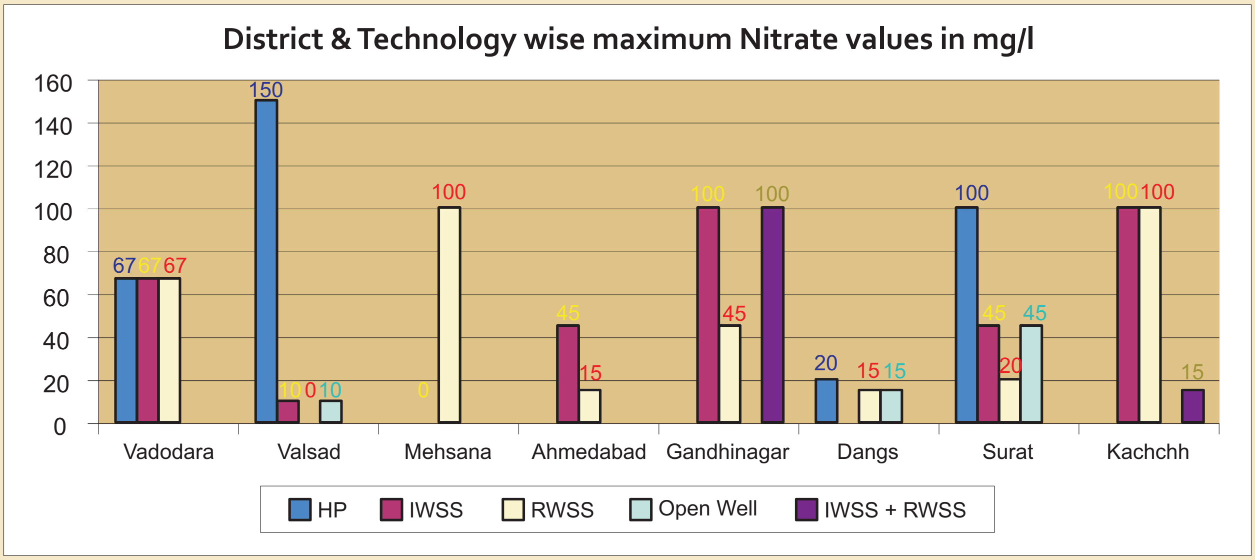
This section is broadly divided into chemical and bacteriological analysis of district and technology wise findings. A relationship between maximum value of a parameter beyond permissible limit is established with percentage of samples having value higher than permissible limits.

Chemical Analysis

From chemical contamination point of view, Gujarat state is primarily affected by water quality problem of nitrate, fluoride and salinity. Hence, all the three parameters have been included for the chemical analysis, as follows:

1. Nitrate

As per IS 10500 revised guidelines [ed. 2.2 (2003-09)], permissible limit of Nitrate in potable water is 45 mg/l. Following graph gives a district and technology wise maximum nitrate value in mg/l:



The maximum nitrate value of 150 mg/l was found in hand-pump technology of Valsad district. However maximum occurrence of samples having values higher than permissible limit of Nitrate was found in Hand-pumps of Vadodara district (44% of hand-pump samples).

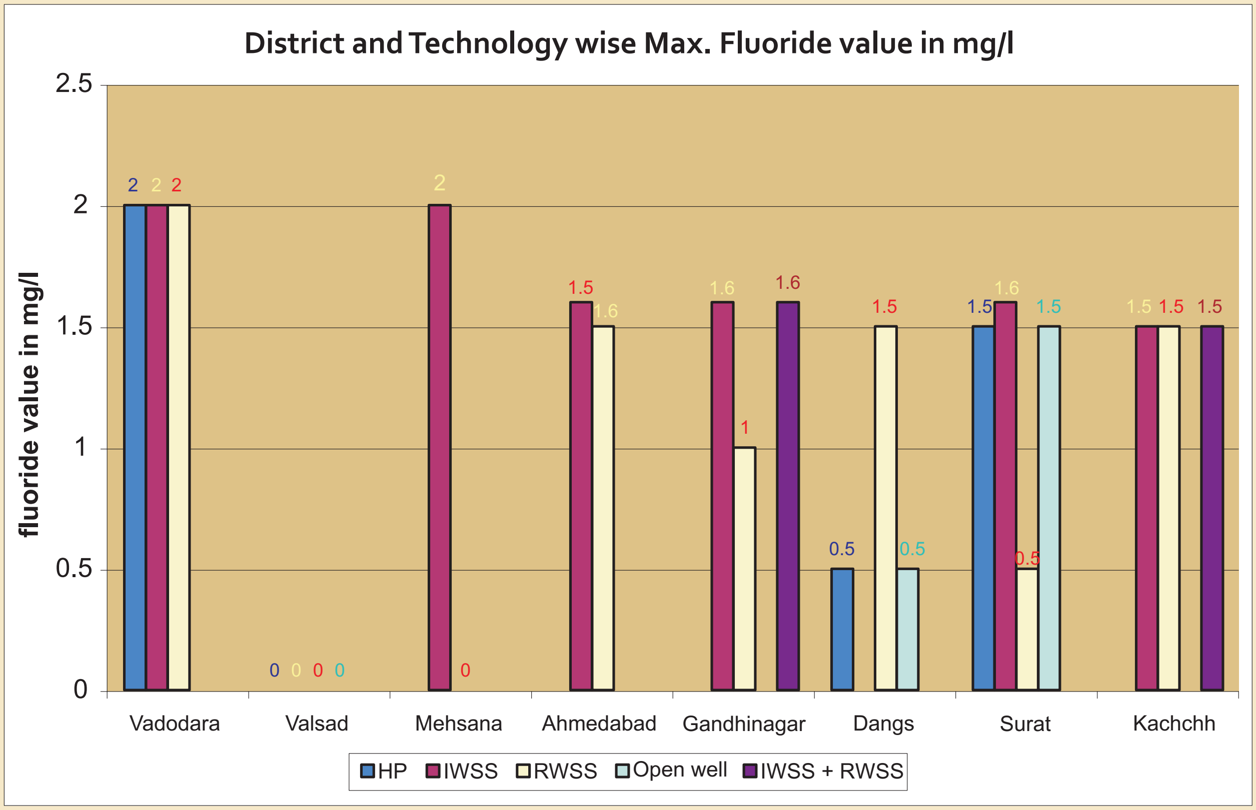
% of sample having values higher than permissible limit - Nitrate

District	HP	IWSS	RWSS	Open well	IWSS + RWSS
Vadodara	44	29	5		
Valsad	2	0	0	0	
Mehsana		0	0		
Ahmedabad		0	0		
Gandhinagar		25	0		30
Dangs	0		0	0	
Surat	1	0	0	0	
Kachchh		3	0.4		0

It was observed that 30% of IWSS + RWSS samples tested also had nitrate value higher than 45mg/l. This is attributed due to local mixing of unfit source of water, which needs to be critically looked into.

2. Fluoride

As per IS 10500 (1991) guidelines, permissible limit of fluoride in potable water is 1.5 mg/l. Following graph gives a district and technologwise maximum fluoride value in mg/l



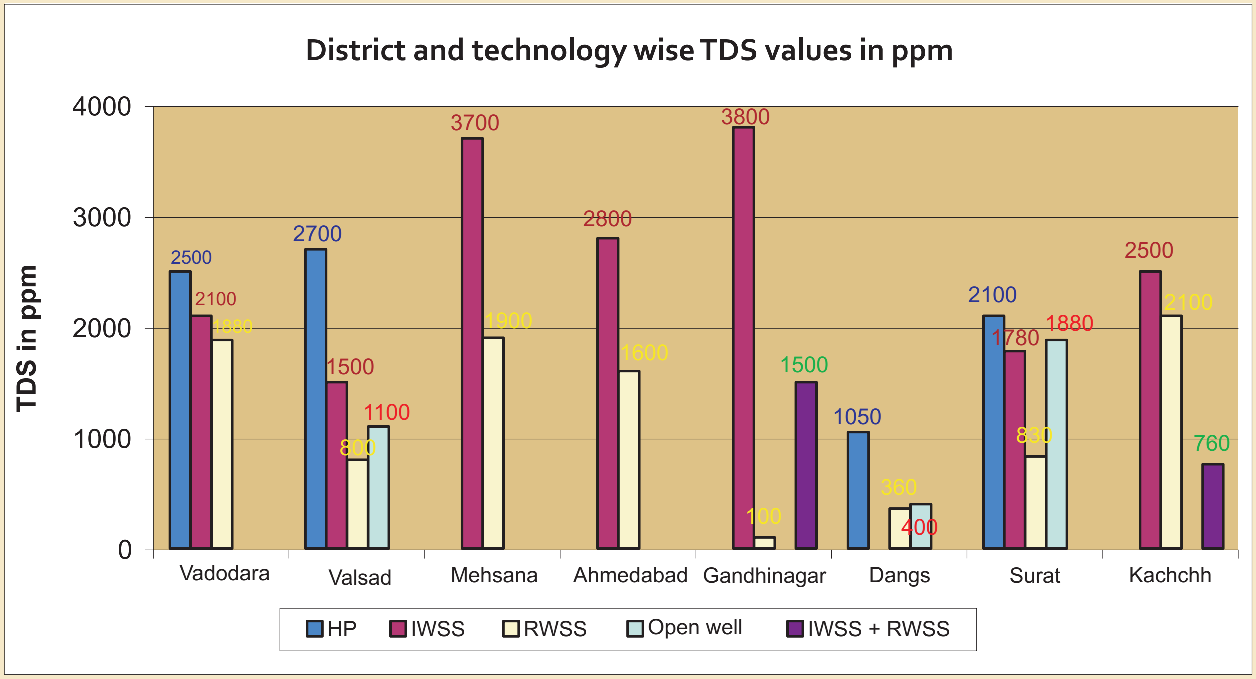
% of sample having values higher than permissible limit – Fluoride

District	HP	IWSS	RWSS	Open well	IWSS + RWSS
Vadodara	27	7	10		
Valsad	0	0	0	0	
Mehsana		31	0		
Ahmedabad		9	0		
Gandhinagar		10	0		2
Dangs	0		0	0	
Surat	0	3	0	0	
Kachchh		0	0		0

It was found that fluoride values were as high as 2 mg/l in all the technologies serving Vadodara district. 27% of the hand pump samples tested in Vadodara district had fluoride value higher than permissible limit. It was found that nitrate value in IWSS technology in Gandhinagar, Ahmedabad and Surat of about 1.6 mg/l.

3. Total Dissolved Salts (TDS)

As per IS 10500 (1991) guidelines, permissible limit of TDS in potable water is 2000 ppm. Following graph gives a district and technology wise maximum TDS value in mg/l:



% of sample having values higher than permissible limit – Total Dissolved Salts

District	HP	IWSS	RWSS	Open well	IWSS + RWSS
Vadodara	3	2	0		
Valsad	4	0	0	0	
Mehsana		12	0		
Ahmedabad		15	0		
Gandhinagar		0.38	0		0
Dangs	0		0	0	
Surat	1	0	0	0	
Kachchh		2	1		0

It was found that TDS values were as high as 3800 ppm in IWSS of Gandhiangar district. In Ahmedabad district about 15% samples tested had TDS values higher than permissible limit of 2000 ppm.

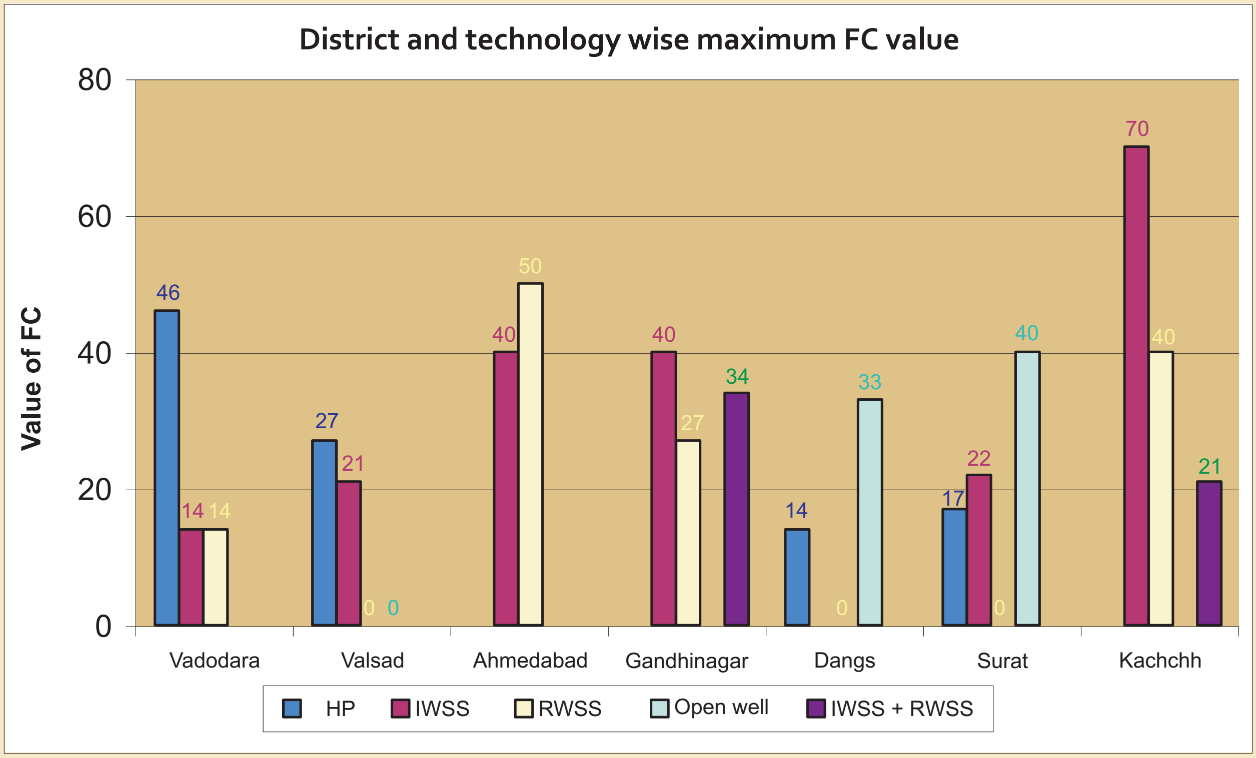
If we analyse samples keeping the upper limit of TDS as 1000 ppm [desirable limit as per IS 10500 (1991)], the % samples values higher than desirable limit would be as high as 50-60% in almost all districts except Dangs and Valsad.

Micro-biological Analysis

It is a well established fact that bacteriological contamination is critical as it has potential of creating water borne diseases. Feacal Count (FC) is one of the important indicator for bacteriological contamination, hence it has been analysed for all the samples which were tested positive in test carried out on H_2S vial bottles.

TTC and FS parameters were tested through Wagtech Kit in M-DAWS pilot district – Vadodara. For other M-DAWS districts, H_2S vials were used for primary assessment of bacteriological contamination. If the result was found to be positive, samples were given for detailed laboratory analysis, where Feacal Count (FC) was assessed instead of TTC & FS.

1.Feacal Count (FC)



% of sample having FC values higher than 2

District	HP	IWSS	RWSS	Open Well	IWSS + RWSS
Vadodara*	12	9	4		
Valsad	1	4	0	0	
Ahmedabad		73	52		
Gandhinagar		68	86		56
Dangs	3		0	25	
Surat	1	21	0	76	
Kachchh		31	40		23
*Vadodara values are of Feacal Streptococci					

A direct relationship was observed between FC count and sanitary condition near the source from where sample is collected. This relationship is explained in detail in section dealing with sanitary surveillance.

From the above table, it is clear that sanitary condition near sources of Ahmedabad, Gandhinagar, Kachchh and Surat is very poor and requires urgent attention. Behaviour change in community and end users through focuses IEC activities can bring about posivite results.

2. Thermo Tolerant Coli form (TTC) & Feacal Streptococci (FS)

The maximum value of TTC and FS in samples of Vadodara district was in range of 21-26 and 46-14 respectively for different technologies.

3. Residual Chlorine

Residual chlorine of 0.2 mg/l at user end is a desirable amount which provides protection from bacteriological contamination. It was observed that all the contaminated samples did not have any residual chlorine. Hence, adequate amount of chlorination provided is strongly advocated.

Sanitary Surveillance

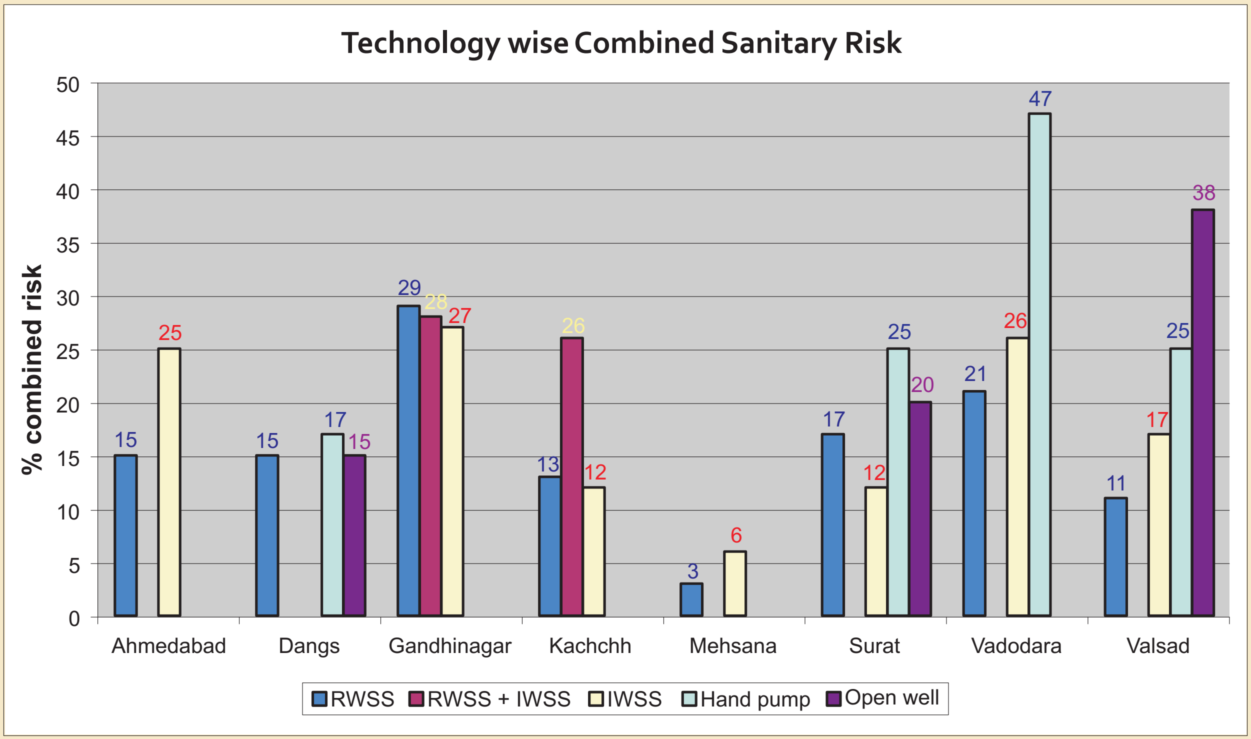
Sanitary Surveillance is one of the important parameter on which micro-biological quality of water is dependent. General observation during M-DAWS field visit reflects that sanitary condition around water source leads to contamination and deterioration in water quality.

The micro-biological contamination is the prime contributor for water borne diseases such as diarrhea, dysentery, etc. Hence, sanitary surveillance of district and technology wise was carried out as a part of M-DAWS study.

Highest sanitary risk observed was 47% for Hand-pump technology is Vadodara district. Open well in Valsad district had a combined risk of 38% whereas RWSS in Gandhinagar district had combined risk of 29%. The combined sanitary risk ranged from 11 – 47% across different technologies and districts.

In following section, water supply technology and district wise sanitary risk is compared. This comparison shall facilitate decision maker for suggesting corrective action to reducing sanitary risks.

The technology wise combined sanitary risk is depicted as follows:



1. Sanitary Risk of RWSS technology (in %)

Sr. No.	Sanitary Surveillance	Vadodara	Valsad	Dangs	Mehsana	Kachchh	Gandhinagar	Ahmedabad	Surat
1	Missing taps	26	25	26	2	18	0	15	15
2	Leaking taps	24	25	36	2	17	0	7	20
3	Loose housing of tap stands	9	10	3	1	11	0	3	3
4	Wastewater collected in 2 m	39	35	46	3	31	43	37	35
5	Open pipeline within 5 m	10	0	0	2	6	14	4	0
6	Human excreta within 10 m	11	0	2	1	9	29	11	13
7	Other sources of pollution within 10 m	38	0	10	3	12	86	13	25
8	Free animal access	47	30	41	4	23	86	34	46
9	leakage in pipes within 50 m	12	0	2	0	3	29	2	0
10	Bathing/washing on platform	29	10	10	13	24	57	49	49
11	Leaks in collection sump	3	0	4	1	0	0	0	0
12	Open cover of collection sumps	3	0	0	1	6	0	0	1
Combined risk of each parameter		**21**	**11**	**15**	**3**	**13**	**29**	**15**	**17**

The highest risk observed in RWSS is of '*free access to animal'* & '*other sources of pollution'* - (89%) followed by 'bathing/ *washing on platform'* in Gandhinagar district. In Dangs '*waste water collected in 2 m'* had about 46% sanitary risk. The combined risk of each parameter was highest in Gandhinagar district (29%) and lowest in Valsad district (11%). Immediate attention pertaining to sanitary condition near water sources is recommended for Gandhinagar district.

1. Sanitary Risk of (RWSS + IWSS)[1] (in %)

Sr. No.	Sanitary Surveillance	Kachchh	Gandhinagar
1	Missing taps	31	11
2	Leaking taps	31	11
3	Loose housing of tap stands	46	6
4	Wastewater collected in 2 m	92	39
5	Open pipeline within 5 m	15	9
6	Human excreta within 10 m	0	20
7	Other sources of pollution within 10 m	0	86
8	Free animal access	38	64
9	leakage in pipes within 50 m	8	34
10	Bathing/washing on platform	38	50
11	Leaks in collection sump	8	0
12	Open cover of collection sumps	0	0
Combined risk of each parameter		**26**	**28**

The highest risk observed in RWSS+IWSS is of 'waste *water collected in 2 m',* which was as high as 92% in case of Kachchh as compared to 39% in Gandhinagar. However, *'free access to animal'* had risk factor of 64% in Gandhinagar as against 38% in Kachchh.

2. Sanitary risk of IWSS (in %)

Sr. No.	Sanitary Surveillance	Vadodara	Valsad	Mehsana	Kachchh	Gandhinagar	Ahmedabad	Surat
1	Missing taps from tap stand	29	15	4	7	28	23	7
2	Leaking taps	25	26	5	13	16	7	14
3	Tap stand not firmly fitted	26	19	0	11	8	4	4
4	Broken platform < 1.85 m	34	40	9	24	40	53	16
5	Open pipe within 5 m	13	2	1	2	10	2	2
6	Human excreta within 10 m	9	4	2	4	27	13	3
7	Other sources of pollution within 10 m	23	13	7	9	55	24	16
8	Free animal access	45	32	11	14	31	50	27
9	leakage in pipes within 50 m	8	1	1	1	16	2	2
10	Bathing/washing on platform	47	19	15	39	37	68	31
Combined risk of each parameter		**26**	**17**	**6**	**12**	**27**	**25**	**12**

The highest risk observed in IWSS technology is of 'other *sources of pollution'* - (55%) in Gandhinagar district followed by *'broken platform < 1.85 m'* in Ahmedabad district. The combined risk of each parameter was highest in Gandhinagar district (27%) and lowest in Surat and Kachchh districts (13%).

This particular technology (RWSS + IWSS) was added after field visit to Kachchh and Gandhinagar district. The local source is used as supplementary to RWSS water supply, in case of inadequacy or irregularity in water supply. Many times local blending of water also takes place.

3. Sanitary risk of Hand Pumps (in %)

Sr. No.	Sanitary Surveillance	Vadodara	Valsad	Surat	Dangs
1	Toilet within 10 m	9	3	6	1
2	Free access to animals	95	42	60	37
3	Other sources of pollution < 10 m	66	27	40	11
4	Broken platform < 1.85 m	47	44	30	33
5	Wastewater collected on platform	51	43	33	25
6	No waste gutter or choked	61	46	21	25
7	Ponding of water within 3 m	29	19	28	19
8	Missing/ corroded pump cover	6	1	7	8
9	Loose junction of HP with apron	15	2	13	7
10	Bathing or washing on platform	92	24	12	1
	Combined risk of each parameter	**47**	**25**	**25**	**17**

Hand-pumps are normally installed in remote tribal and hilly areas where piped water supply is not economically viable. Hand pump technology was mainly found in Vadodara, Valsad, Surat and Dangs district.

The highest risk observed in Hand pump technology is *'free access to animals'* which was as high as 95% followed by *'other source of pollution < 10 m'* in case of Vadodara. In Valsad sanitary risk associated with *'no waste gutter or choked'* was found to be at 46%.

4. Sanitary Risks of Open well (in %)

Sr. No.	Sanitary Surveillance	Valsad	Surat	Dangs
1	Toilet within 10 m	0	2	0
2	nearest toilet located at level higher than open well	0	2	0
3	any source of pollution within 10 m of open well	72	29	13
4	water accumulated within 2 m of open well	47	24	4
5	wastewater gutter broken or blocked - water logging	41	10	0
6	open well parapet less than 1 m or absent	25	19	0
7	cement platform less than 1 m in periphery of open well	66	12	17
8	open well walls inadequately sealed upto 3 m	28	21	0
9	cement platform broken/ cracked leading to contamination	25	19	25
10	rope and water container not kept properly	56	31	25
11	well open without cover	94	69	92
Combined risk of each parameter		**38**	**20**	**15**

Open wells are still common in Valsad, Surat and Dangs district. The highest sanitary risk was observed in Valsad (94%) and Dangs (92%) of *'well open without cover'*. The other critical sanitary risk associated with open well are *'other source of pollution within 10 m'* and *'cement platform less than 1 m in periphery of open well'*.

Identified Water Quality related Issues and possible Remedial Measures

This concluding section based on detailed M-DAWS analysis carried out in 8 districts identifies issues and proposes suggestive remedial measures along with responsible departments/ people, so as to improve water quality reaching to the end-users:

No.	Identified Issues	Remedial Measures	Responsibility
1.	Presence of fecal contamination due to improper disposal of faces	• Stopping of open defecation by construction of toilet facility under TSC programme. Care should be taken that sanitation unit is about 10 m away from the water source.	• Rural Dev. Dept. • Education, ICDS & Health dept.
2.	Exposed pipelines / leakage in distribution	• Regular O & M of the system by water board's field team • Strengthening of O&M skills of *pani samiti* for minor repairs at stand-post, household level	• GWSSB/ WASMO field team
3.	Irregular water supply (leading to mixing of water from unfit sources)	• Ensuring safe source from RWSS/local one to be allocated purely for drinking/cooking purpose and affected local source to be used for other domestic usages	• GWSSB field team • Pani samiti • panchayat
4.	Improper handing of water at user's end	• Ensuring behavioral change aspects pertaining to hand washing with soap and water after defecation and before eating/filling water. • Safe handling of drinking water	• Pani samiti/ panchayat
5.	Quality related issues	• Ensuring source sustainability through Water Resource Management (WRM) interventions.	• WASMO/ GWSSB
6.	Polling of water	• Leakages of water should be immediately repaired so as to avoid pooling. • Pilferage of water should also be stopped through vigilance	• GWSSB local team

7.	Poor samity condition	• Panchayat may frame rules for improving sanitary condition in village. Introduce concept of fine for defaulters and reward for those who help in improving sanitary condition. The fund may come from O&M fund o f *pani samiti.*	• Panchayat • Health dept. • Schools
8.	Free access to animals	• Animal access near water source should be totally banned by rule as well as fencing. • Cattle trough should be placed at least 10 m from the drinking water source.	• Panchayat • Pani samiti
9.	Broken platforms of hand-pumps	• Sensitize local people for avoiding misuse of hand pump platform for using it for washing clothes, cleaning utensils and animals which leads to breaking of platforms	• Mechanical cell, GWSSB • Pani-samiti members
10.	Improper disposal of waste water in vicinity of source	• It can be avoided by proper disposal of waste water through gutter into soak pits near the source/ stand-post, etc. where spillage of water is high.	• Pani samiti • Panchayat

District Specific Critical Issues

M-DAWS findings clearly suggests that residual chlorine was absent in almost all samples tested across districts and technologies. Chlorination is very crucial in ensuring water quality and protection from micro-biological contamination. Hence, it becomes important to ensure adequate chlorination in water sources.

In this section, district-wise three critical issues pertaining to water quality has been depicted based on sanitary surveillance scores.

Sr. No.	District	Identified Issues
1.	Vadodara	• Blending of local unfit water at source • Free access of animals near water source • Pollution around water source
2.	Valsad	• Waste water collected in 2 m of source • Free access of animals near water source • Broken platform and leaking taps
3.	Dangs	• Waste water collected in 2 m of source • Free access of animals near water source • Washing of clothes / pollution around water source

4.	Mehsana	• Free access of animals near water source • Broken platform and leaking taps • Bathing/ washing of clothes on platform
5.	Kachchh	• Free access of animals near water source • Bathing/ washing of clothes on platform • Waste water collected in 2 m of source
6.	Gandhinagar	• Free access of animals near water source • Broken platform and leaking taps • Washing of clothes / pollution around water source
7.	Ahmedabad	• Free access of animals near water source • Broken platform and leaking taps • Washing of clothes / pollution around water source
8.	Surat	• Bathing/ washing of clothes on platform • Free access of animals near water source • Waste water collected in 2 m of source

Conclusions

As explained earlier, unsafe drinking water has serious health hazards, hence its quality has been accorded highest priority in national and as well as international guidelines. There are various physical, chemical and bacteriological parameters, which define quality of drinking water, which has been assessed in M-DAWS study carried out in 8 focus districts.

Broadly, water quality issue can be categorized as source related problem such as inadequacy of water resource or inherent chemical composition of water; behavioral aspects such as poor handling of water and bacteriological contamination due to human induced activities such as open defecation, free access to animals and improper disposal of water.

There has been a significant rise in awareness level of communities pertaining to water quality due to various Government initiatives such as distribution of field testing kits, mobile water quality campaign, pre & post monsoon surveillance, IEC activities and involving schools in monitoring water quality. However, water quality has a very fragile relationship with human interface and environment and hence requires due attention. Hence, behavioral change in communities with help of dedicated IEC is a must to improve or just maintain the quality of water.

Issue of inter-departmental co-ordination has also emerged as one of the critical issues in ensuring water quality. Hence, linkages between Water departments, rural development department, health, education, child development are crucial in maintaining quality of drinking water.

Follow-up Plan

As a follow up of M-DAWS study, a detailed district wise '*Water Safety Plan*' is proposed to be implemented. As a first step, the M-DAWS study findings will be shared at district and state level to draw remedial measures plan.

As a pilot, ***Water Safety Plan*** is proposed in 10 villages of an identified district, where a detailed understanding of water quality is imparted to communities. They would be appraised about relevant issues of Operation & Maintenance (O&M), Water Resources Management, Water Quality aspects. Based on the pilot experience, necessary changes will be made in the programme and then taken up in other districts where M-DAWS has been carried out.

Annexure: DISTRICT PROFILES

Vadodara District

Geography and Demography

Vadodara district is located between longitude 72.51°E to 74.17°E and latitude 21.49°N to 22.49°E. It has an area of 7549.5 sq. km. It has 12 talukas (blocks) with headquarter as Vadodara. It has population of 3.64 million as per 2001 census. There are total 1543 villages. Population density of Vadodara district is 482 persons per sq. km.

Physical and Physiological Parameters

Average rainfall of Vadodara district is 1732 mm. Maximum and minimum temperature in Vadodara district goes upto 44°C during month of May and 8°C during month of January.

Geology and Geohydrological Condition

The area of Vadodara, Karjan, Padra, Dabhoi and Sinor taluka falls under alluvium formation while part of Savli and Waghodia taluka comprise of rocky formation. Sand, silt, clay, kankars and gravels form the alluvium. Ground water occurs under confined to semi-confined condition. Major part of eastern area falls under rocky terrain in which ground water occurrence is poor.

The bore well depth varies from 90 to 120 m. While, in alluvium areas the depth o tube well varies from 60 to 120 m. TDS varies from 500 to 3000 ppm in Shinor, Karjan, Padra, Dabhoi, Savali, Waghodia, while it varies from 250 – 3500 ppm in some part of Sankheda, Jetpur Pavi, Dabhoi, Savli, Waghodia, Naswadi, Chota Udepur and Kawant talukas. High fluoride content is observed in some part of Padra taluka. Ground water quality is also deteriorating day by day in major parts of Vadodara and Karjan talukas.

Due to heavy withdrawal of the ground water and poor recharge, the ground water levels are being depleted and ground water quality is deteriorating.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

- **Over exploited taluka (black):** Vadodara
- **Semi Critical taluka (grey):** Karjan, Shinor
- **Safe taluka (white):** Padra, Savli, Pavi-Jetpur, Chota Udepur, Kawant, Dabhoi, Sankheda, Waghodia, Naswadi

Valsad District

Geography and Demography

Valsad district is situated on southern part of Gujarat. It has an area of 2947.57 sq. km. It has 5 talukas (blocks) with headquarter as Valsad. It has population of 1.41 million as per 2001 census. There are total 454 villages.

Physical and Physiological Parameters

Average rainfall of the district is 2147 mm. Runoff is very high due to uneven & hilly topography. Main Rivers are Par & Daman ganga flowing from east to west and draining in the Arabian Sea. The eastern part of the district is hilly & covered by dense forest.

Geology and Geohydrological Condition

Geologically the area is composed of igneous rocks, mainly Deccan trap basalt & is overlain by thin layer of alluvium (clay, sand, silt & gravels) The Dharampur & Kaprada taluka are hilly & rocky. The Valsad, Pardi & Umargam taluka are covered by Alluvium (clay silt,& sand) & underlain by basalt. There is less overburden in the Dharampur & Kaprada taluka. Recent alluvium formation contains sand silt, clay & gravels. Ground water occurs in weathered portion, cracks, fissures and joints. Excessive runoff causes soil erosion and less recharge.

Valsad, Pardi and Umargam taluka contains alluvium & basalt, while Dharampur & Kaprada taluka are rocky & hilly feasible for drilling of bores (60 to 90mt deep) by DTH Rig. Western part is feasible for drilling by DTH / MDR rig. Salinity prevails in the coastal area, as a result now; the area is covered under Regional water supply schemes for supply of drinking water. In the Dharampur and Kaprada taluka rocks are fresh & massive; as a result bores and wells become seasonal & dry up during summer.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

All talukas of Valsad district namely, Dharampur, Umargam, Pardi, Valsad and Kaprada falls under safe or white zone. p

Mehsana District

Geography and Demography

Mehsana district is situated in the northern part of Gujarat and district headquarter is Mehsana. Mehsana district is situated between latitudes 23^0 00' to 24^0 09' North and longitudes 72^0 05' to 72^0 95' East. Mehsana district has nine talukas, having 593 villages and as per 2001 census total population is 1.65 million people.

Physical and Physiological Parameters

The average rainfall of Mehsana district for last ten years is around 618 mm. physiologically this area is flat except Satlasana and Kheralu taluka. Main rivers of the district are Sabarmati, Rupen, Puspavati, Khari, etc which flow across from NE to SW. Sabarmati river meets Gulf of Khambhat whereas all other rivers disappears into little Rann of Kachchh.

Geology and Geohydrological Condition

Geologically, 85% of the area comprises of alluvial formation in the form of alternate bands of sand and clay. Sandy formations act as groundwater bearing aquifers. Northern part of the district consists of country rock as charnokites, calc-granites and calc-gneisses formation. Remaining part of the district [is formed of Alluvium. Alluvial formation, consist of sand, gravel, clay, pebbles and kankars.

Ground water occurs under confined and unconfined conditions, therefore, the sources of ground water in the area are deep tube wells of 150 m to 400 m depth and 150 mm to 300 mm dia size. Water level in deep tubewells caries from 90 to 140 m. Ground water quality in most part of the district is from 500 to 2000 ppm of TDS. In western part of the district it is 2500 to 3000 ppm. Fluoride concentration in ground water is more than permissible limit in the villages of Kheralu, Satlasana, Vadnagar, Visnagar, Unjha and Kadi taluka, which is around 2 to 3 ppm. Due to excessive fluorides in ground water, villages of east and central Mehsana are covered under a regional water supply scheme based on water of Dharoi dam. Villages of Mehsana, Kadi and Bechraji taluka are covered under Narmada Canal based water supply schemes.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

- **Over exploited taluka:** Becharaji, Kadi, Mehsana, Kheralu, Satlasana, Unhja, Vijapur, Visnagar
- **Critical taluka (dark zone):** Vadnagar

Gandhinagar District

Geography and Demography

Gandhinagar district is situated in the central part of Gujarat and has four talukas with 290 villages and ten urban habitations in the district. District is situated between 23.01' to 23.56'N longitude and 72.33' to 73.73' E latitude. Total area of the district is 2163.48 sq. km and total population, as per 2001 census is 13,34,731 persons.

Physical and Physiological Parameters

Average rainfall in Gandhinagar district for last decade is 698 mm. Main rivers of the Gandhinagar district are Sabarmati, Meshwo and Khari which originate from Aravalli hills and meet in the gulf of Khambhat. The topography of the district is almost even. General flow of district is north to south.

Geological and Geo-hydrological Condition

Geologically the Gandhinagar district is covered with quaternary alluvium formation of Cambay basin. Rocky area is not found in this district. The alluvial formation is made up of multi-layer sand, silt and clay formation. Alluvium thickness is more in western side of the district, while less in eastern side. Silt, clay dominates alluvium found in the northwest side while coarse-grained sand with gravels is common in the eastern part. Tertiary clay (blue clay) occurs at different depths in the area. It demarcates the potable water boundary, below which water quality deteriorates. In the eastern part it occurs at very shallow depth i.e at 40 to 50 m restricting drilling depth up to that depth.

Ground water occurs in semi-confined to confined and in un-confined conditions. Total depth of the bore in east side is ranging from 50 to 180 m, while in northwest side, depth of the bore varies from 200 to 350 m. Presently village water supply schemes are mainly based on ground water through tube-wells. Water level of the district is depleting very fast due to less recharge and un-controlled withdrawal.

The quality of the ground water is also deteriorating very fast. TDS ranging in the ground water from 700 to 2500 ppm. In certain area fluoride occur more than permissible limit in certain pockets of Mansa, Kalol and Gandhinagar talukas. Water level of Gandhinagar district is depleting 3-4 m per year as per the report total ground water development of the district is 205% and falls under over exploited category, where ground water development is more than 100%.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

Over exploited taluka: Mansa, Kalol, Gandhinagar, Dehgam

Ahmedabad District

Geography and Demography

Ahmedabad district is located in central part of Gujarat. There are 11 talukas and 556 villages in this district. Total area of the district is 7932-43 sq. km and as per 2001 census report population is 5.81 million.

Physical and Physiological Parameters

Average rainfall of last ten years is 637 mm. Main River is Sabarmati, which originates from Aravalli Ranges of Rajasthan and meeting to sea in the bay of Cambay.

Geology and Geohydrological Condition

Geologically the area consists of Quaternary alluvium. The south west area viz. part of Barvada, Ranpur and Dhandhuka is made up of Basalt rock. While rest area of the district is consist of alluvial formation, which is made up of alternate beds of Clay and Sand.

Geohydrologically, major parts of the district consist of alluvial formation. Alluvial formation is made up of Sand, clay, kankers, silt and gravels. In this formation water is available under confined and unconfined conditions. Remaining area is made up of basalt, which is very poor in ground water availability and yield. Sufficient discharge is available from alluvial formation. Average depth of tube-well in eastern part ranges from 90-120 m and in north- west part it is 350 to 400 m.

Generally water supply schemes of Ahmedabad district are based on deep tube- wells. Due to heavy drilling activity and over extraction of ground water since last two decades, there is a sharp decline in water levels and in the quality of water. As far as water quality is concerned, TDS in the area ranges from 800 to 3500 ppm. In some areas fluoride content is more than permissible limits.

Due to poor availability and quantity of ground water supply, project to affected villages through Narmada pipeline is under progress.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

- **Over exploited taluka (black zone):** City and Dascroi
- **Critical taluka (Dark zone):** Dholka, Sanand, Detroj, Rampura
- **Semi Critical taluka (grey zone):** Bavla, Barvala, Mandal, Viramgam
- **Safe taluka (white zone):** Ranpur
- **Saline Taluka:** Dhandhuka

Surat District

Geography and Demography

Surat is the main district of South Gujarat and is known for its cotton and diamond business. Surat City is head quarter of the district situated on the bank of River Tapi. Geographical area of the district is 7,451 sq. km. It has 14 talukas and 1278 villages. The population of district is 49,96,391 persons as per 2001 census.

Physical and Physiological Parameters:

The average annual rainfall of last 10 years is 1376 mm. The main river Tapi originates from Satpuda mountain ranges and meets Arabian Sea in the west. The other rivers Kim, Mindhola, Purna and Ambika originate from east, and flows westward. The Ukai and Kakrapar are the main dams on river Tapi.

Geologically, the central to eastern belt of district comprises of Deccan trap basalt of cretaceous-Eocene age, which is overlain by quaternary alluvium. Limestone & clay formation of Eocene ages are found in north & central west area, is overlain by soil whereas from central to western most part of the district, quaternary alluvium formation is seen.

Generally in rocky areas Hand Pump bores are drilled for drinking water. In some village where ground water availability is good, water supply is based on bores. In the alluvium area water supply scheme of villages is based on tube wells, but the saline areas water is being supplied through RWSS based on surface sources.

In the district, ground water level ranges from 6-40 m in central to eastern most areas where as in alluvium areas it ranges from 6-15m. In central and eastern belt, the ground water is generally potable where TDS ranges from 300-1800 ppm. While in coastal belt of Olpad, Choryasi taluka it ranges from 200-10000 ppm. In some of Nizar and Uchchhal taluka nitrate is noticed 100 – 130 ppm in ground water which may be due to excessive use of fertilizers. The talukas like Mahuva, Bardoli, Kamrej and Mangrol in some area fluoride is notices above 1.5 ppm.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

- **Semi (grey) Critical taluka:** Choryasi
- **Safe (white) taluka:** Nizar, Olpad, Mangrol, Umarpada, Uchhal, Mandavi, Palsana, Vyara, Bardoli, Songadh, Kamrej, Mahuva

Dang District

Geography and Demography
The Dang district is situated in the Southeast Part of Gujarat state. The Dang district has Ahwa taluka with 311 villages. Total area of the district is 1764 sq km.

Physical and Physiological Parameters

Average Rainfall in the area is 2718 mm, which is highest rainfall in the state. The 73% area of Dang district is covered under reserved and protected forest. Main rivers of Dang district are Purna, Ambika, Khapri, which flows east to west. In spite high rainfall the district experiences problem of drinking water in summer season. This is due to steep slopes causing heavy run-off.

Geology and Geohydrological Condition

Geologically, the district is composed of Deccan trap Basalt, which is hard in nature. There are less cracks, fissures, and joints. Basalt acts as poor aquifers.

Drinking water sources are mainly hand-pumps, wells and RWSS. Water quality is very good & potable in general. This is only fluoride free district in the state. The general depth of the bores is 90 m for hand pumps. In 88 villages, water is being provided by RWSS. The TDS value ranges from 200 to 400 ppm. The water level in the well ranges from 4 to 9 m and in the bores it is 12 to 24 m.

For water recharging and conservation, in 2003-04 and 2004-05 total 8 and 22 check dams were constructed under 11th finance commission funding.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

- **Safe taluka (white zone):** Ahwa - Dang

Kachchh District

Geography and Demography
Kachchh district is the largest district in Gujarat having total area of 45,612 sq. km. It lies between 2244'08" to 2441'30" N Latitudes and 687'23" to 7104'45" E Longitude. The total population as per 2001 Census is 15,82,759 persons.

Physical and Physiological Parameters

Topography of the district is uneven and about 50 of area is covered by flat, marshy, saline rann, while remaining area is occupied by two major hill ranges - Jhara and Laki. Kachchh district is traversed by 97 minor and major rivers all of them are non-perennial, and most of these flow from Central high land area to South direction. Average Rainfall of last 10 years the district is 312 mm.

Geological and Geo-hydrological Condition

Geologically, district comprises of old lower Jurrassic formation to recent alluvial formation. The extreme Northern part comprises of great saline Rann. In South, along seacoast, it is represented by recent alluvial formation and in West Tertiary formation is seen in Lakhpat & Abdasa talukas. Saline formation is seen in the Rapar taluka. Central and southern part of the district is covered by basalt. Groundwater in most area is brackish to saline. Central part and east – west portion of district, yield potable water, and the southern area yields potable to brackish water from confined aquifers. The central & southern part of district occupied by basaltic formation yield limited quantity of potable water from unconfined aquifer.

The water level ranges 24-45m in east and west direction. In central part it is raning 90-125 m. The average depth of source ranges between 75 – 125m in east and west part and in central part it ranges between 135 – 180m.

The Kachchh district has limited area of potable water and water supply to the villages of the Kachchh district is mainly through 124 RWSS having their sources in the proven tube well zone. Erratic and scanty rainfall and over-pumping of ground water has caused deterioration in the quality of ground water. To improve this situation, GWSSB has started recharge activities.

Summary of ground water scenario: *(GWSSB, WASMO 2006)*

- **Over exploited taluka (black zone):** Anjar, Bhachau, Mandavi
- **Critical taluka (Dark zone):** Rapar
- **Semi Critical taluka (grey zone):** Bhuj, Mundra, Nakhatrana, Abdasa
- **Safe taluka (white zone):** Lakhapat

Saline Taluka: Gandhidham

M-DAWS credits

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Building partnerships and working together

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