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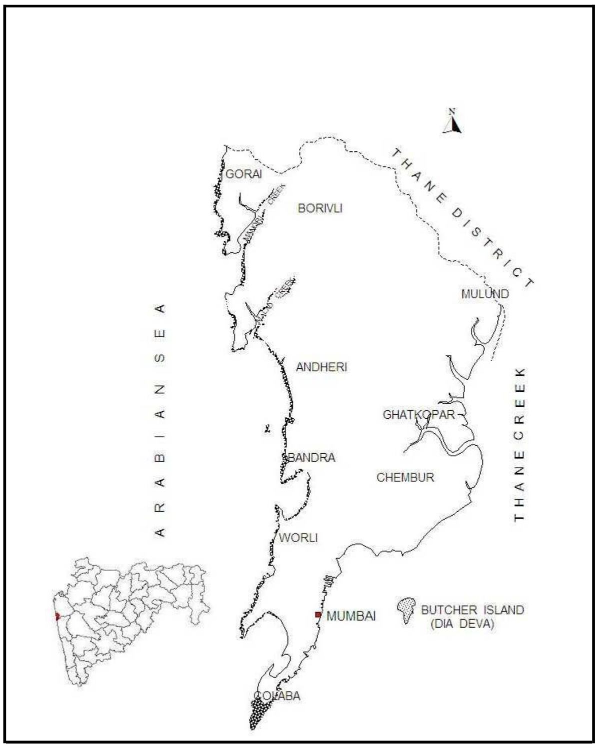
भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूजल बोर्ड

GOVT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

महाराष्ट्र के अंतर्गत बृहन मुंबई जिले की भूजल विज्ञान जानकारी

GROUND WATER INFORMATION GREATER MUMBAI DISTRICT MAHARASHTRA



By
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Scientist-D

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सौरभ गुप्ता
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मध्य क्षेत्र, नागपुर

CENTRAL REGION, NAGPUR
2013

GREATER MUMBAI DISTRICT AT A GLANCE

1. GENERAL INFORMATION

Location	:	North latitude- 18°53' & 19°19' East Longitude- 72°47' & 72°59'
Geographical Area	:	603 sq. km. (Mumbai City- 69 sq. km.; Mumbai Suburb- 534 sq. km.
Population (2001)	:	11,914,398
Temperature	:	Maximum - 32.2°C; Minimum - 16.3°C
Normal Annual Rainfall	:	1800 mm to 2400 mm

2. GEOMORPHOLOGY

Major Physiographic Units	:	2; Hill Ridges with intervening Valleys and Coastal Plains
Major Drainage	:	2; Mahim and Mithi

3. SOIL TYPE

2; Medium to deep black and reddish soil

4. GROUND WATER MONITORING WELLS (As on 30/12/2012)

Dugwells	:	3

5. GEOLOGY

Recent	:	Alluvium
Upper Cretaceous To Lower Eocene	:	Basalt (Deccan Trap), Rhyolite and Trachyte

6. HYDROGEOLOGY

Water Bearing Formation	:	Basalt–Jointed/Fractured/Weathered Vesicular and Massive Basalt River/Marine Alluvium- Sand and Gravel
Premonsoon Depth to Water Level (May-2011)	:	2.65 to 4.25 m bgl
Postmonsoon Depth to Water Level (Nov.-2011)	:	2.00 to 5.00 m bgl
Premonsoon Water Level Trend (2001-2011)	:	Rise: 0.02 to 0.04 m/year
Postmonsoon Water Level Trend (2001-2011)	:	Rise: 0.02 to 0.05 m/year

7. GROUND WATER QUALITY

Suitable for drinking in areas at higher elevation but high concentration of pollutants is high at low lying areas..

8. MAJOR GROUND WATER PROBLEMS AND ISSUES

Though the quality of ground water is potable in major part of the district, but pollution of ground water is a major problem of the district. The main source of pollution is the sewage and industrial effluents which are being disposed indiscriminately into the surface water bodies. In addition to this, various industrial effluents from oil refineries, reactors, fertilizers have polluted the ground water and as a result the concentration of heavy metals in ground water in the surrounding areas of creek has observed to be beyond the permissible limits. The Ground water in the district is quite vulnerable to contamination from leakage of sewage pipelines. Apart from this, the rampant increase in exploitation of ground water for commercial purpose like construction purposes, hotel industry and for domestic purpose of the housing societies is quite common in entire district which may lead to landward ingress sea water.

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Greater Mumbai District

1.0 Introduction

Greater Mumbai is located on the western most periphery of the Maharashtra State. The city in the past (year 1885) was comprised of elongated shaped group of seven islands viz., Bombay, Mazgaon, Matunga, Mahim, Worli, Soyster Rode and Old Woman's island which over the period of time, have been connected to main land by series of reclamation measures such as filling of narrow creeks etc. The area of was further extended by adding suburban areas in the north and along the border of Thane District. Location f the district is shown in Fig 1.

The Mumbai city is known as financial capital of India. Due to continuous expansion of infrastructural facilities, industries, and commercial units in the city, a wide business and massive employment opportunities have been generated. Many people from western Maharashtra, Konkan and other states came to Mumbai in search of employment. Therefore continuous migration has resulted into over-crowding of the city.

The population of Greater Mumbai as per 2001 census is 11,914,398 which includes population of city (3,326,837) and its suburb (8,587,561). It is the third most populous city in the world after Tokyo and Sao Paulo. The population of city is projected to be 20.5 million in year 2011A.D. It is observed that population has doubled every 20 years.

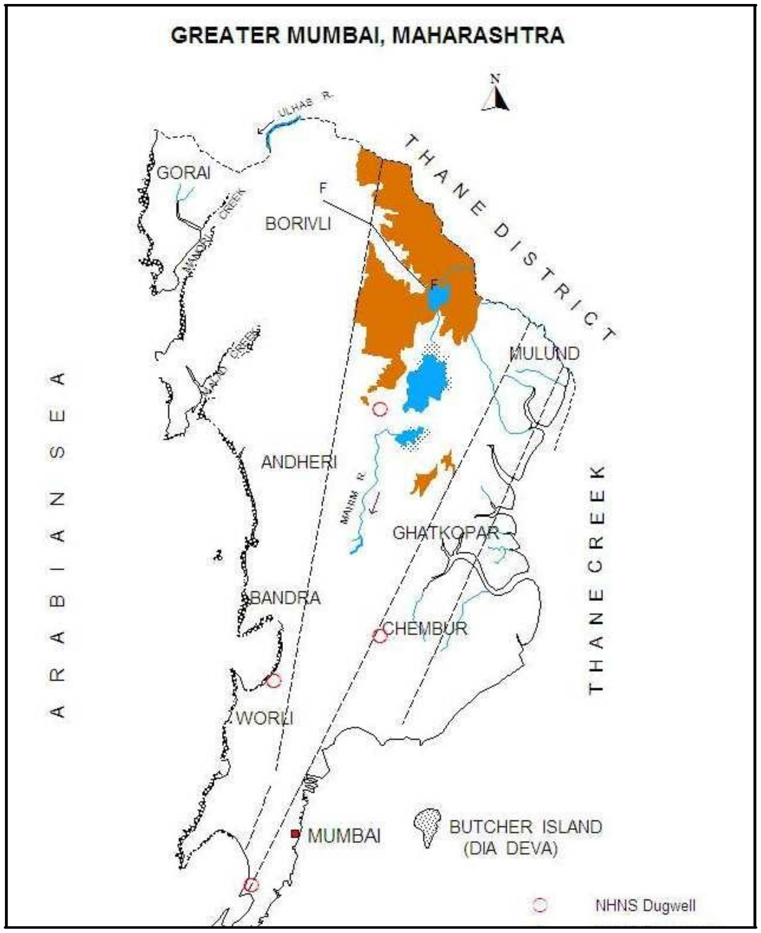

Figure-1: Location

2.0 Climate and Rainfall

The climate of the district is characterized by an oppressive summer, dampness in the atmosphere nearly throughout the year and heavy south – west monsoon rainfall from June to September. The mean minimum temperature is 16.3℃ and the mean maximum temperature is 32.2℃ a t Santacruze.

The normal annual rainfall over the district varies from about 1800 to about 2400 mm. It is minimum in the central part of the district around Kurla (1804.9 mm). It gradually increases towards north and reaches a maximum around Santacruze (2382.0 mm).

3.0 Physiography and Soil Type

The broad physiographic feature of the district is broad and flat terrain flanked by north – south trending hill ranges. The hill ranges form almost parallel ridges in the eastern and western part of the area. The Powai – Kanheri hill ranges are the other hills extending in the eastern and central part running NNE – SSW. The maximum elevation of the area is 450 m above mean sea level (m amsl) at some of the peaks of hill ranges. Trombay island has north – south running hills with maximum elevation of 300 m above man sea level. Malbar, Colaba, Worli and Pali hills are the isolated small ridges trending north – south in the western part of the district. The Powai – Kanheri hills form the largest hilly terrain in the central part of the Salsette island and are the feeder zone for the three lakes viz., Powai, Vihar and Tulsi. There are a number of creeks, dissecting the area. Among them, Thane is the longest creek. Other major creeks are Manori, Malad and Mahim which protrudes in the main land and give rise to mud flangs and swamps.

The area is drained by Mahim, Mithi, Dahisar and Polsar rivers. These small rivers near the coast, form small rivulets which inter mingle with each other resulting in swamps and mud flats in the low lying areas.

Two types of soils have been observed in the district viz., medium to deep black and reddish soil.

4.0 Status of Water Supply

4.1 Availability of Water from Surface Water Sources:

The entire Greater Mumbai is an urban area. All the major surface water reservoirs located in surrounding districts which are situated on major rivers, are used for water supply. These rivers are the Vaitarna, the Ulhas, which originate in Konkan region, and other rivers are the Patalganga and the Amba. Even though these rivers do not flow through Greater Mumbai but their basins form the major source of surface water for Greater Mumbai as a whole for its domestic and industrial consumption. The Mumbai Hydrometric Area (MHA) under Department of Irrigation, Government of Maharashtra, comprises these four river basins. They have a total catchment area of 5756 Sq. Km. The total surface water potential of MHA is estimated to be 10439 Million Cubic Meter (MCM) at 75% dependability and 7869 MCM at 90% dependability. The basin-wise available surface water is given in table – 1.

Table1. Basin wise water Availability to Greater Mumbai

Sl. No.	Basin	Catchment (Sq. Km)	Water availability At 75% dep. (MCM)	Water Availability at 90% dep. (MCM)	Irrigation requirement as planned (MCM)	Water Available for Domestic & Industrial Supply (MCM)
1.	Vaitarna	1858	3130	2416	651	2416
2.	Ulhas	3205	6194	4881	1241	4881
3.	Patalganga	338	712	489	147	489
4.	Amba	365	403	283	146	257
	Total	5756	10439	7869	2157	7843

Water supply to Mumbai city is dependent on six lakes viz Tulsi, Vihar, Tansa, Upper Vaiterna, Bhatsa and Mumbai III. The source wise water supply through lakes is given in Table 2:

Table 2. Water Supply Sources to Greater Mumbai City.

Sources	Yield (MLD)	Percent
Tulsi	18	0.54
Vihar	110	3.28
Tansa	417	12.45
Upper Vaitarna	1025	30.60
Bhatsa	1650	49.25
Mumbai-III	150	4.48
Sub-total	3350	100
En-route supply	120	-3.58
Total water supply	3230	96.42

4.2 Ground Water Supply:

Ground water is not suitable for drinking purposes. In order to mitigate the risk of epidemic, Brihanmumbai Municipal Corporation (BMC) and Government of Maharashtra (GoM) have banned the use of water from wells and ponds for domestic use. As a result, the dug well based water supply is completely discouraged. However, the population growth in the city is very high as compared to other parts of the country and to meet the shortfall in water supply, ground water supply as a supplementary source has been used for all purposes than domestic. Total 3950 dug wells and 2514 bore wells (BMC records) are under operation for water supply purpose in the city. The aquifers in the district are of limited areal extent and of limited thickness. Ground water is quite vulnerable to contamination from sewage disposal and other human activities. The over pumping may also lead to sea water ingress.

4.3 Future Water Supply:

The projected demand of water for Greater Mumbai for the year 2021 is estimated to be 5355 Million Litre Per Day (MLD). To meet this additional requirement of water, four water supply projects are under construction and by the completion of these projects the total supply will rise to 5479 MLD. The sources identified for augmentation of water supply are as below in Table 3.

Table 3: Identified Sources of Water Supply

Source of Sater (Future Projects)	River	Water Supply Capacity (MLD)
Middle Vaitarna	Vaitarna	455
Gargai	Vaitarna	455
Pinjal	Vaitarna	865
Kalu	Ulhas	590
Shai	Ulhas	1067

4.4. Demand of Water:

As per norms of Central Public Health and Environmental Engineering, Ministry of Urban Development, the water supply for cities with population above one lakh is 150-200 litres per capita per day (1pcd). For Greater Mumbai, the water is being supplied @ 150 lpcd at present which may rise to 200 lpcd by 2011 and 225 lpcd by 2021. The total gross domestic and industrial requirement (taking norm as 150 lpcd) is given in the Table 4.

Table 4. Gross Water Requirement for Greater Mumbai.

Sl. No.	**Type of use**	**Water Requirement (MLD)**	**Water Requirement (MLD)**	**Water Requirement (MLD)**
		1991	**2001**	**2011**
1.	Domestic	1489	2200	3080
2.	Industrial Institutional	400	400	400
3.	Other uses	38	54	69
4.	En route	90	90	90

	Total (Net)	2017	2823	3819
	Total (Gross)	**2521**	**3529**	**4525**

5.0 Ground Water Scenario

5.1 Hydrogeology

The entire district is underlain by basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow Alluvium formation of Recent age also occurs as narrow stretch along the major rivers flowing in the area. A map depicting the hydrogeological features is shown in Figure 2.

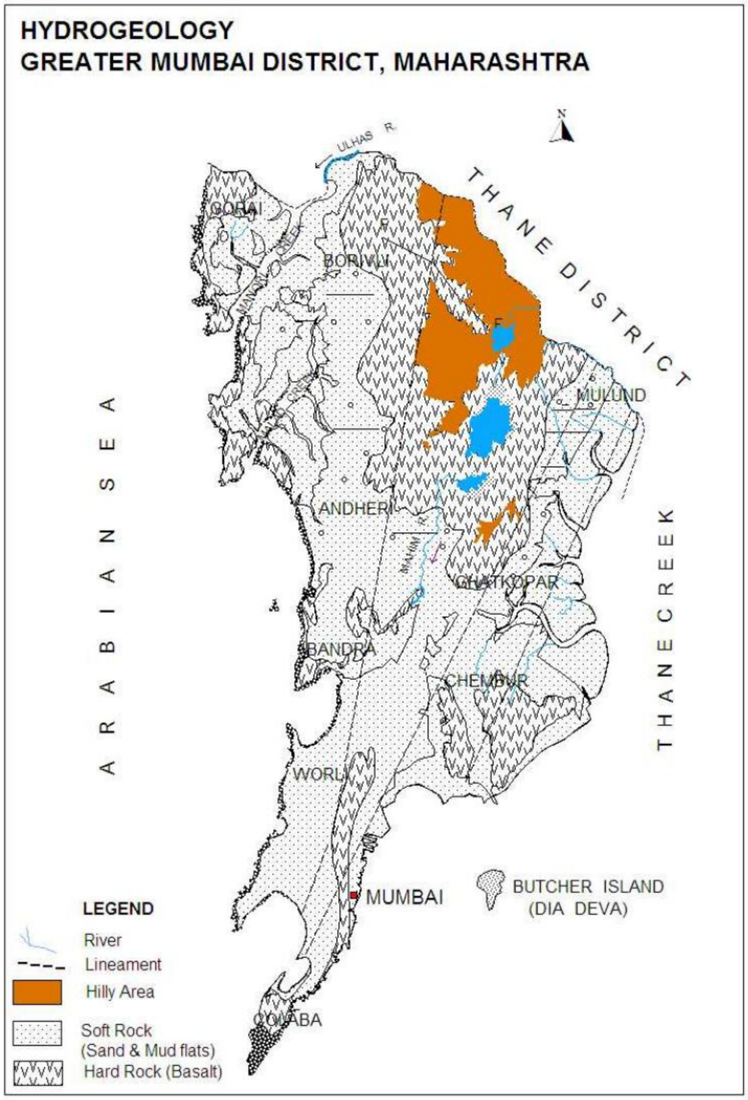

Figure-2: Hydrogeology

5.1.1 Hard Rock Areas

5.1.1.1 Deccan Trap Basalt

The 'Pahoehoe' flows in the district consist of highly vesicular layer having closely spaced horizontal joints but the thickness is generally less. The vesicles are generally filled with secondary minerals and green earths. In such cases, they do not serve as aquifer. However, such vesicular zones are weathered in most part of the area, thus, making them moderately permeable. But if, vesicles are not filled, they act as highly permeable aquifers. The simple and compound “Pahoehoe” flow comprises a basal vesicular zone, middle relatively massive portion followed by a vesicular top. The vesicles of “Pahoehoe” flows are generally not interconnected and thus there is a variation in water holding capacity from the base to the top of the flow.

The ground water exists in fractures, joints, vesicles and in weathered zone of Basalt. The occurrence and circulation of ground water is controlled by vesicular unit of lava flows and through secondary porosity and permeability developed due to weathering, jointing, fracturing etc., of Basalt. The ground water occurs under phreatic, semi confined and confined conditions. The leaky confined conditions are also observed in deeper aquifers. Generally the phreatic aquifer range down to depth of 10 m bgl. The yields of the wells are the functions of the permeability and transmissivity of aquifer encountered. This varies with location, diameter and depth of wells. There are mainly two types of ground water structures i.e. dugwells and borewells in the area. The yields of the dugwells varies form 10 to 1000 m^3/day, whereas that of borewells ranges between 50 and 1000 m^3/day tapping the promising aquifer in the depth range of 40 to 60 m bgl. Even though the borewells drilled in the area by both official and private agencies, are in large number, no adequate data regarding areal extent of the aquifer is available. The borewells in low lying area are affected by saline water where as in upland areas the quality is potable.

5.1.2 Loose Formation

5.1.2.1 Alluvium

River Alluvium patches along the course of rivers and Marine Alluvium in the coastal area, form highly potential aquifer but with limited areal extent. The ground water occurs under water table conditions in sandy / gritty layers. The alluvial fill of low lying areas underlain by weathered basalt has relatively better ground water potential.

5.2 Water Level Scenario

Central Ground Water Board periodically monitors 3 National Hydrograph Network Stations (NHNS) in the district, four times a year i.e. January, May (Premonsoon), August and November (Postmonsoon).

5.2.1 Depth to Water Level – Premonsoon (May-2011)

The premonsoon depth to water levels monitored during May 2011 ranges between 2.67 m bgl and 4.25 m bgl. The depth to water levels during premonsoon occurs in 2.0 to 5.0 m depth range.

5.2.2 Depth to Water Level – Postmonsoon (Nov.–2011)

The depth to water levels during postmonsoon (Nov. 2011) in major part of the district ranges between 2 and 5 m bgl. The Shallow water levels of < 2 m bgl are observed in small area in southern part of the district.

5.2.3 Seasonal Water Level Fluctuation (May to Nov 2011)

Seasonal water level fluctuation between premonsoon and postmonsoon of 2011 have been computed and observed that seasonal it ranges from 0- 2.0m.

5.2.4 Water Level Trend (2001 – 2011)

Trend of water levels for premonsoon and postmonsoon periods for last ten years (1998-2007) have been computed for 3 NHNS. Analysis of long term water level trend data indicates rise of water levels in the range of 0.02 to 0.04 m/year during premonsoon and rise in the range of 0.02 to 0.05 m/year during postmonsoon. This marginal rise in water level may be due to leakages from water supply pipe lines.

5.3 Ground Water Quality

CGWB is monitoring the ground water quality of the Mumbai district since the last four decades through its established monitoring wells. The objectives behind the monitoring are to develop an overall picture of the ground water quality of the district. During the year 2011, the Board has carried out the ground water quality monitoring of 4 monitoring wells. These wells mainly consist of the dug wells representing the shallow aquifer. The sampling of ground water from these wells was carried out in the month of May 2011 (pre-monsoon period). The water samples after collection were immediately subjected to the analysis of various parameters in the Regional Chemical Laboratory of the Board at Nagpur. The parameters analyzed, include pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Nitrate (NO_3) and Fluoride (F). The sample collection, preservation, storage, transportation and analysis were carried out as per the standard methods given in the manual of American Public Health Association for the Examination of Water and Wastewater (APHA, 1998). The ground water quality data thus generated was first checked for completeness and then the validation of data was carried out using standard checks. Subsequently, the interpretation of data was carried out to develop the overall picture of ground water quality in the district in the year 2011.

Suitability of Ground Water for Drinking Purpose

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. Though many ions are very essential for the growth of human, but when present in excess, have an adverse effect on human body. The standards proposed by the Bureau of Indian Standards (BIS) for drinking water (IS-10500-91, Revised 2003) were used to decide the suitability of ground water. The classification of ground water samples was carried out based on the desirable and maximum permissible limits for the parameters viz., TH, NO_3 and F prescribed in the standards and is given in **Table-5**.

Table-5: Classification of Ground Water Samples for Drinking based on BIS Drinking Water Standards (IS-10500-91, Revised 2003)

Parameters	DL	MPL	Samples with conc. < DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
TH (mg/L)	300	600	4	-	-
NO_3 (mg/L)	45	No relaxation	4	-	-
F (mg/L)	1.0	1.5	4	-	-

(Here, DL- Desirable Limit, MPL- Maximum Permissible Limit)

The perusal of **Table-5** shows that the concentrations of all the parameters are the within the desirable limit of the BIS standards. It is also seen from the **Table-5** that the potability of ground water in the wells is not much affected. Overall, it can be concluded that the ground water quality in the wells monitored in the district is within the BIS Standard condition.

The quality of ground water of deeper aquifer is brackish to slightly saline in some localities such as Colaba, Dharavi, and Khar as observed from BMC data. This may be due to ingress of sea water. In view of this it is suggested that the bore wells drilled especially along the coastal areas should be pumped at the optimum discharge, so that it does not result in sea water ingress.

5.4 Status of Ground Water Development

Ground water development depends on many factors viz., availability, crop water requirement, socio-economic fabric and on the yield of the aquifers existing in that area. Ground water in the district is predominantly used for domestic, industrial and commercial purpose in the form tanker water supply to the hotel industry, construction purpose etc. The ground water development in the district is mostly through dugwells and borewells. The utilization of ground water through borewells is more in the Andheri, Malad, Goregaon, Kandivili, Bhandup, Kurla, Chembur and Ghatkoper areas. In addition to this, new borewells are being drilled in every upcoming society/colony to partially cater to the domestic requirements. Similarly new borewells are taken up in the industrial areas to cater to their partial needs.

6.0 Ground Water Management Strategy

At present there is less significance of ground water development in the district owing to the limited availability as compared to huge demands of large population. The ground water development is quite low due to quality issues and low yielding nature of aquifers etc.

6.1 Ground Water Development

The ground water is presently developed through dugwells and borewells. The hydrogeological set-up and disposition of rock types show that availability of ground water resources will be limited to ground water worthy areas mostly located in Salsete island and limited areas of Bombay and Trombay islands. About 500 to 800 wells can be constructed if the yield of wells is considered to be 30 to 50 m^3/day. In these areas the ground water can be developed through dugwells and borewells/tubewells. However the sites for borewell/ tubewells need to be selected only after proper scientific investigation and they should only be used for drinking water supply and not for industrial and commercial purposes. The promising and productive aquifers exist in the depth range of 60 to 80 m bgl. In view of this, it is expected that deeper aquifers can offer additional quantity of ground water especially where borewells are high yielding. In the Alluvial areas, shallow dugwells of 5 to 10 m depth, whereas in Deccan Trap Basalt areas dugwells of 7 to 15 m depth are the most feasible structures for ground water development. The ground water quality also needs to be ascertained and the wells used for water supply should be first checked for nitrate and other pollutants

Even though ground water is available in the area, more emphasis is given on creating surface water reservoirs, rather than developing ground water in a planned way. The conjunctive utilization of available surface and ground water in a systematic and planned way will be the best solution for meeting present and future demands of water.

6.2 Water Conservation and Artificial Recharge

The artificial recharge structures feasible are recharge shafts/borewells, whereas water conservation can be done through roof top rain water harvesting. Existing dugwells/borewells can also be used for artificial recharge, however, the source water should be properly filtered before being put in the wells. These sites need to be located where the hydrogeological conditions are favourable, i.e., where sufficient thickness of unsaturated/de-saturated aquifer exists and water levels are more than 5 m deep. The postmonsoon depth to water level map and premonsoon/postmonsoon water level trend map gives a good idea of areas suitable for artificial recharge of ground water and such areas are limited in extent and located in north central part of the district, where water levels are moderately deep and falling water level trends are also observed. In other areas with shallow water levels, roof top rain water harvesting is also feasible by storing rainwater in storage tanks, thereby supplementing the main source of water.

7.0 Major Ground Water Problems and Issues

The pollution of ground water as well as surface water is the major problem in the district. The creeks in the region have become the dumping ground of sewage and industrial effluents. In addition to this, various industrial effluents from oil refineries, reactors, fertilizers plants at Chembur have polluted the sea water in eastern part and are hazardous to marine life.

The data of Maharashtra Pollution Control Board (MPCB) indicate concentration of Mercury (Hg) more than the prescribed limit of 1.90 ppm. The alkali and dye industries are responsible for mercury pollution in the Thane creek. The higher Arsenic (As) concentration of more than 2.00 ppm and slightly more is observed in fishes from Thane and Chembur. The other heavy metals like Lead (0.60 ppm), Cadmium (12.60 ppm) and Copper (8.84 ppm) are also reported from creek water.

Ground water exploitation for commercial purpose is carried out in entire district and the water is extracted from existing dugwells and borewells, even new borewells are also being drilled for this purpose. The ground water is used for construction purposes, hotel industry and for domestic purpose of the housing societies. Excessive ground water development in the beach and coastal areas can lead to saline water intrusion as observed in some parts of Colaba, Dharavi and Khar from BMC data.

8.0 Recommendations

1. The availability of ground water resources is limited to ground water worthy areas mostly located in Salsette island and limited areas of Bombay and Trombay islands. About 500 to 800 wells can be constructed if the yield of wells is considered to be 30 to 50 m^3/day.
2. In these areas the ground water can be developed through dugwells and borewells/tubewells. However the sites for borewell/ tubewells need to be selected only after proper scientific investigation and they should only be used for drinking water supply and not for industrial and commercial exploitation.
3. In the Alluvial areas shallow dugwells (5 to 10 m), whereas in Deccan Trap Basalt areas dugwells (7 to 15 m) are the most feasible structures for ground water development.
4. The conjunctive use of available surface and ground water in systematic and planned way will be the best solution for meeting present and future demands of water.
5. Ground water exploitation for commercial purpose needs to be regulated as the ground water is extracted from existing dugwells and borewells, even new borewells are also being drilled for this purpose leading to saline water intrusion in beach and coastal areas.
6. The scope exists for constructing suitable artificial recharge

structures like recharge shafts/borewells in some areas located in north central part of the district . The existing dugwells/borewells can also be used for artificial recharge, however, the source water should be properly filtered before being put into the wells.

7. Roof top rain water harvesting is also feasible by storing rainwater in storage tanks in areas with shallow water levels, thereby supplementing the main source of water.

8. There are thousands of industrial units of various types. These industries cause pollution to ground water and even to surface water. Besides this the city is heavily populated, at very high population density the sanitation facility is quite inadequate which has given rise to nitrate pollution in the district. The special studies in Chembur area revealed presence of Cu, Cr, Ca, As, Hg in ground water which are extremely harmful. In view of the above, it is imperative that a well detailed study should be conducted demarcate the areas of safe drinking water.