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GOVT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

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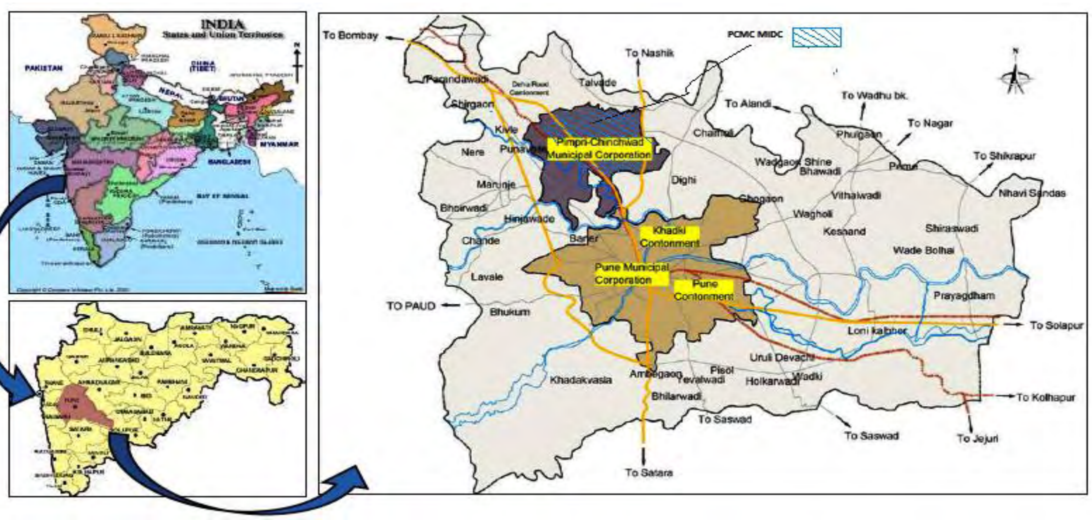
GROUND WATER CONTAMINATION IN INDUSTRIAL CLUSTER OF PIMPRI CHICHWAD, PUNE DISTRICT, MAHARASHTRA

(AAP 2010-11)



By
Upendra Dhonde
Asst. Hydrogeolgist
Supervised by
Sourabh Gupta
Scientist-D

दवारा
ऊपेन्द्र धोंडे
सहायक भूजल वैज्ञानिक
अधीक्षण
सौरभ गुप्ता
वैज्ञानिक -घ

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GROUND WATER CONTAMINATION IN INDUSTRIAL CLUSTER OF PIMPRI CHINCHWAD, PUNE DISTRICT, MAHARASHTRA

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GROUND WATER CONTAMINATION IN INDUSTRIAL CLUSTER OF PIMPRI CHINCHWAD, PUNE DISTRICT, MAHARASHTRA

1. INTRODUCTION

Maharashtra State is one of the industrially developed states of India. The formation of Maharashtra Industrial Development Corporation (MIDC) has boosted the industrial development by creating basic as well as most advanced infrastructure facilities for various types of industries in many parts of the State. Though, state of art facilities were provided for water supply, effluent treatment and waste disposal for the industries, yet the possibilities of pollution may exist in many industrial areas. Ground water contamination has been reported due to discharge of untreated/partially treated industrial effluents. The industrial effluents contain a variety of chemicals, dyes, acids and alkalis besides heavy metals and other toxic compounds. Textile dyes are toxic, highly stable and do not degrade easily and are not removed by conventional wastewater treatment methods. Untreated effluent of textile / chemical industries drains or seepage from their holding/storage ponds contaminates ground water regime. Such activities put hydrological stress on existing ground water by deteriorating its quality. The present study is under taken to assess the impact of industrial pollution on water resources especially the ground water. The investigation is taken up during September 2010 with the aim to identify pollution of ground water, its sources and suggest possible remedial measures.

1.1 Purpose and Scope

Water pollution is one of the major global environmental problems, especially in industrial clusters. Pimpri-Chinchwad is one of the most prominent industrial hub of the State. There is growing concern on the deterioration on the deterioration of ground water quality due to industrial effluents, being discharged without proper treatments without hydrogeological considerations i.e lack of proper discharge sites. The industrial effluents generated from the metallurgical, chemical, mechanical, electrical and refinery industries are the main source of ground water pollution. The high permeability of weathered, fractured basalt and alluvial aquifers existing at shallow depth give rise to favorable condition for transportation of contamination into ground water. Water pollution is increasing and becoming severe day-by-day and posing a great risk to human health and other living organisms. Water pollution can be defined as the **c**ontamination of water by physicochemical and biological pollutants into the water making it unfit for drinking and other purposes. Continuous application of polluted groundwater for irrigation can also increase the soil salinity or alkalinity problems in farmlands.

Since industrial pollutions are the most common threat to the ground water regime; special studies were carried out to ascertain level of contamination to ground water, source of contamination and its remedial measures. The report discusses the various types of ground water contaminants with respect to industrial development in MIDC cluster/enclave of Pimpri- Chinchwad area of Pune. Apart from identification of ground water contamination, measures to protect the water resources are brought out in detail. The hydrogeological conditions, ground water chemistry and contamination are discussed in detail in the following chapters of the report.

1.2 Location, Extent and Accessibility

Pimpri-Chinchwad is a part of city in Pune Metropolitan Region of Maharashtra. It is situated South-East of Mumbai and in the North-West part of Pune. It is well connected to Pune city via the Old Pune-Mumbai Highway. The MIDC has set up an industrial centre in Pimpri-Chinchwad region, in an area of 12.24 sq.km, covering Chinchwad, Pimpri, Bhosari, Nigadi towns. The location coordinates of the industrial area are 18°37' to 18°42'N latitude and 73°44' to 73°50'E longitude. The area fallins within in Pimpri Chinchwad Municipal Corporation and is situated between Pavana & Indrayani Rivers.

Pimpri Chinchwad being adjacent to the Pune enjoys the excellent connectivity. The city is well connected by road, rail and air to almost all important cities in India. It is situated on the confluence of NH-4 (Mumbai-Bangalore Highway) and NH-50 (Pune-Nasik Highway). The city is connected to the Mumbai through Mumbai Pune Express way.

2.0 HYDROMETEOROLOGY AND PHYSIOGRAPHY

2.1 Rainfall

Pimpri-Chinchwad experiences three distinct seasons: summer, monsoon and winter. Typical summer months are from March to May, with temperatures ranging from 35 to 39°C (95 to 102°F), the warmest month being April. The city receives moderate annual rainfall of 722 mm, mainly between June and September, as a result of the SW monsoon. However, there is wide variation in rainfall from west to east i.e from 900 to 500 mm respectively.

The winter is from November to February, when day temperature is around 29°C (84°F), while the night temperature dips below 10°C (50°F) for most of December and January, often dropping to 5 or 6°C (40-42°F).The highest temperature recorded at Pimpri Chinchwad was 43.3°C (110 °F) on 30th April 1987 and 7th May 1889, while the lowest temperature recorded was 1.7°C (35°F) on 17th January 1935. The maximum relative humidity during the rainy season is 70-80%, and falls as low as 30% in summer afternoons.

2.2 Physiography and Drainage

Physiographically, the study area is a part of Deccan Plateau. The industrial set up is developed mostly around relatively flat areas. The east-west ridge running midway between Indrayani and Pavana rivers separates this area into two parts. The northern portion slopes towards Indrayani river while the southern portion slopes towards Pavana river.

Area is situated on the banks of Pavana and Indrayani Rivers, at an average altitude of 530 to 566 m above mean sea level. Pavna and. Indrayani rivers traverse the outskirts of the area and drain into Bhima River. Thus, the area is located in upper Bhima basin. The western part of the area is hilly, having an average altitude of 600 - 800 meters. In general, the area has overall slope towards east. The extreme West, Southwest and Southern part is characterised by hilly and rugged topography.

2.3 Soils

Generally, major part of the study area is covered by black cotton soil called regur formed by weathering of trap rocks. Sandy soil and older alluvial deposits of the Indrayani and Pawna Rivers are also found in pockets along the banks of these rivers.

5.0 GEOLOGY

The area is underlain by different basaltic lava flows, belonging to Deccan Traps of Upper Cretaceous to Lower Eocene age. At times, these flows are inter-bedded with agglomerates and tuffs. Basaltic flows of Deccan Trap formation are mostly exposed in the area. However, at places they are covered by laterites, soils, marshy land and alluvium along the river courses. The general geological sequence is as follows…

Period	Formation	Lithology
Recent	Alluvium	Soil, Kankar, Clay, Silt, Sand
Cainozoic	Laterite	Reddish to deep brown, Pisolitic
Upper Cretaceous to Lower Eocene	Deccan Trap	Basaltic lava flows with inter-trappean beds

3.1 Deccan Traps

The basaltic lava flows of the Deccan Trap is the major rock formation of the area. Predominantly the Deccan Trap flows are simple “aa” types. The aa flows generally show a thin zone of grayish basal clinker, a prominent middle section of dark dense rock and a top section of reddish altered breccia. The breccia comprises of angular and rounded reddish vesicular or massive trap pulverized rock material zeolites. The top surface of aa flows are represented by several centimeters of red bole. The middle dense section shows columnar or rectangular joints and conspicuous spheroidal weathering. All the Pahoehoe and aa flows are seen to have horizontal disposition with minor tilts here and there. In general they show a gentle easterly dip of 1 in 300 to 1 in 110.

3.2 Alluvium

The alluvium consisting of clay, sand and gravel mostly occur in small lenticular patches mostly along the bank of rivers towards the northern and eastern part of the study area. The shallow alluvium ranges in thickness from less than a meter to 18 m and directly overlie the Deccan Traps. The loosely cemented sands and gravels are probably derived from the traps. Besides the above patches, thin alluvium covers are also found at the banks of small streams occurring in area.

6.0 HYDROGEOLOGY

Hydrogeology is concerned primarily with the mode of occurrence, movement and distribution of water occurring in the sub surface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological framework that is nature of rock formation including their porosity (primary and secondary) and permeability. Hydrogeological details of the wells inventoried are presented as Annexure-I. The entire area is underlain by the basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow alluvial 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 as Plate-I.

4.1 Ground Water Abstraction Structures

4.1.1 Deccan Trap

To study the hydrogeology of the area, a total 10nos of dug wells were inventoried in and around the MIDC area. The depth of wells inventoried ranges from 4.81 to 18.0 m.bgl and depth to water level in the month of September, ranges from GL to 6.10 m.bgl. The aquifer encountered at shallow depth is weathered and fractured part of the basalt (Annexure-II). The dug wells are generally developed in valley or topographically low areas. The yield of dug wells tapping phreatic aquifer ranges between 85 and 152 cum/day. The diameter of bore wells range from 115 to 150 mm, but majority of bore wells are having 150 mm diameter, whereas the depth ranges from 60 to 92 m bgl. The bore wells have a discharge of 2 to 4 lps. It is noticed and reported that the yields of the wells drastically get reduced in summer months beginning form March up to June end or onset of monsoon.

4.1.2 Alluvium

The alluvium, which is largely of fluvatile origin , is confined to river banks. No alluvial deposit is seen within and down stream of industrial cluster.

4.2 Depth to Water Level

Depth to water level varies depending upon hydrogeological framework, level of ground water development and topography of the area. It also varies with time. General ground water rise, during monsoon and decline after monsoon till the next monsoon, is witnessed in the region. The water levels monitored from dug wells during May and November 2011 are given in Annexure-II and the same have been used in preparation of premonsoon and post monsoon depth to water level (DTW) maps and the area has been demarcated into various DTW zones viz less than 2m, 2-5m, and more than 5m. Following is the description of the depth to water level during different seasons.

4.2.1 Pre-monsoon Depth to Water Level (May 2011)

The premonsoon depth to water level ranges between 2.20 and 6.85 m bgl in the area. In the major part of the MIDC area, the water level ranges from 2.0 -5.0m.bgl, whereas water level of more than 5.0 m is observed around Rahatani, Moshi-Dudulgaon and Kalas, as isolated patches. The water level is generally shallow as the piped water supply from MIDC is sufficient to meet the domestic and industrial requirement. Thus usage of ground water is very less. However, water level below 5.0 m.bgl are observed at few locations as isolated patches outside the MIDC area, which is not covered by piped water supply and ground water extraction is for irrigation as well as domestic purpose (Plate-II).

4.2.2 Post-monsoon Depth to Water Level (November 2012)

The post monsoon depth to water levels ranges between 1.10 to 4.34m.bgl in the area. Shallow water level of less than 2.0 m.bgl is observed in central parts of the area whereas water level of more than 2.0 m is observed around Rahatani, Moshi-Dudulgaon and Kalas, as isolated patches (Plate-III).

4.2.3 Seasonal Water Level Fluctuation (November – May 2012

The seasonal fluctuation in major part of the MIDC area ranges from 0.0 to 2.0 m (Plate IV). The higher fluctuation of more than 2.0m is observed in the out skirts of MIDC area, may be due to higher utilization of ground water.

5.0 PIMPRI CHINCHAWAD INDUSTRIAL CORPORATION

5.1 Major Industries

Pimpri Chinchwad is a major industrial hub and hosts one of the biggest industrial zones in Asia. Industrialization dates back to 1954 with starting of Hindustan Antibiotics Limited. This town is home to the Indian operations of major automobile companies like Premier Limited, Mahindra Navistar, Bajaj Auto, TATA Motors (formerly TELCO), Kinetic Engineering, Force Motors (formerly Bajaj Tempo), Daimler Chrysler and Autoline Industries. In addition to this, several heavy industries, such as Forbes-Marshall, Thermax, Thyssen Krupp and Alfa Laval & Sandvik Asia have their manufacturing units in the town. Also, the German company KSB Pumps, Swedish bearing company SKF and Rajiv Gandhi Infotech Park hosting several Software and Information Technology majors like Accenture, IBM India, KPIT Cummins, Tata Technologies, Infosys, Wipro, Geometric Limited, Finolex cables limited, SQS India, Info systems Pvt. Ltd., BNY Mellon (India) etc. are the key industries of PCMC area .Chakan is now home to a Special Economic Zone (SEZ) promoted by the Maharashtra Industrial Development Corporation (MIDC). It has evolved into a major automobile hub. It hosts automobile production plants for the Volkswagen Group, Mercedes Benz, Mahindra & Mahindra and Bajaj Auto.

5.2 Water Supply

The main source of water supply to industrial corporation is Pawana River. MIDC draws 75 MLD of water. The MIDC is supplying water to industries and partly to Residential zone. M/s Pudumjee Pulp & Paper Mills draws 11 MLD of water for the industrial purpose as well as for supply to residential zone in and around the industry. The Corporation is having good water distribution and supply network in residential and industrial zones. Presently, all water supply schemes are having water treatment facilities at their respective water supply centres. Pimpri Chinchwad Municipal Corporation (PCMC) has dug up 527 bore wells in the past eight years out of which a total of 283 borewells are in usable condition while the remaining 244 borewells are not in usable condition (PCMC Environment Report 2012-13).

5.3 Industrial Pollution

In the PCMC industrial area, total 816 no. of industries exists. Out of which, large scale are 46, medium scale are 46 and small scale industries are 724. Approximately 13,181 CMD industrial and 17,960 CMD domestic effluents are generated in the area. The large and medium scale industries have treatment facilities for the treatment of both the types of effluents. These units have primary and secondary treatment and some industries have tertiary treatment facilities. The small scale units have primary treatment and some units secondary treatment facilities. The units like Bajaj Auto, Exide, SKF Bearing Ltd., have connected sewage effluent to Corporation drainage line for treatment in the Corporation Sewage Treatment Plants.

5.3.1 Major Polluting Industries

5.3.1.1 Paper & Pulp:

M/s Pudumjee Pulp & Paper Mills and M/s Pudumjee Agro Ltd.,are the Paper manufacturing units.. The paper units use maximum water for processing. These units have provided treatment facilities such as aerobic followed by anaerobic. Though they provide effluent treatment plant (ETP) but the main problem is of lignin recovery. The industry does not have lignin recovery plant. Therefore the Pollution Control Board recently has issued closure directions to stop pulping activity. Now the industry is using readymade pulp for manufacturing of paper. These industries have been directed to recycle the treated water and reuse in the industrial process.

5.3.1.2 Pharmaceutical Industry

In the area, one pharmaceutical industry unit viz M/s Hindustan Antibiotics Ltd., is in existence. This unit is Govt. undertaking. It has primary and secondary treatment plant for the treatment of trade effluent. But the facilities are inadequate and need upgradation. Presently, the unit is running intermittently. The BIFR has declared the unit as sick unit. The other pharmaceutical units are mostly formulations based and have effluent treatment facilities.

5.3.1.3 Automobile Industries

Mainly M/s Bajaj Auto Ltd., M/s SKF Ltd., M/s Telco Ltd. and M/s Bajaj Tempo Ltd. are the major industries and they have provided treatment facilities. The performance of ETP is observed fairly well.

5.3.1.4 Electroplating Industries

These are small scale units. They have primary treatment and some units have secondary treatment facilities too. It is seen during the visit that these units are not maintaining standards. The officials are continuously taking follow-up with electroplating units to provide full-fledged treatment and upgrade ETP. But the progress is not considerable.

5.4 Surface Water Pollution

Approximately 1.13% of PCMC area is covered by surface water bodies. Indrayani and Pawana rivers, reservoirs, ponds and few lakes, etc. are the surface water bodies. These water bodies are in use for agriculture & aquaculture and domestic water supply to nearby residents. The water bodies are vulnerable to pollution due to discharge from industrial effluents, anthropogenic activities, dumping of solid wastes etc. The PCMC had carried out pollution studies of these water bodies. The physio-chemical and biological parameters viz. pH, COD, BOD, DO and total coliform, were analyzed as per standard methods. The results of the studies are as follows:

Pawana and Indrayani rivers, the nalas (tributaries) meeting into these rivers and the ponds appears to be highly polluted. The pollution is mainly due to discharge of nallah water carrying untreated sewage, ashanbhumi (cremation) waste, industrial wastewater etc. The average value of COD in surface water bodies is reported within the permissible limits of 150 mg/l, while BOD is found above the prescribed limit i.e. 30 mg/l which is harmful for agriculture, fishery etc. Besides, excessive presence of total suspended solids (TSS), total coliform and DO level of less than 2 mg/l is also observed by MPCB in the river water.

8.0 GROUND WATER POLLUTION FROM INDUSTRIES

6.1 Methodology and Data Source

To study the pollution impacts of industrial effluents on groundwater, water samples were collected from open wells located in and around the MIDC area. These Samples were preferably collected from the wells located adjacent to the polluting industry and the polluting river/nala courses. Two set of samples were collected in clean and dry plastic bottles of 1000ml capacity. Total ten ground water samples were collected from open wells in and around the MIDC for analysis of chemical parameters as well as same number of acidified ground water samples were collected for analysis of heavy metal content. These samples were analysed at Regional Chemical Laboratory, CGWB, CR, Nagpur. These samples were analyzed for various chemical parameters such as PH, Electrical Conductivity EC, Total Alkanity TA, Total Hardness TH, Nitrate NO_3 and Flouride(F) and for heavy metals such as Cu, Mn, Fe, Pb, Zn.. The standard sampling protocols and analytical methods (procedures) were followed. The results of chemical analysis in respect of important and selective constituents and heavy metal content are given in Annexure-III. The physical and chemical characteristics of ground water are described are given below:

6.2 Physico-Chemical Characteristics of Ground Water

The concentrations of various gases and ions dissolved in water from the atmosphere, soil strata, minerals and rocks with which it comes in contact determine the characteristics of water. This ultimately decides the quality of groundwater. The concentration of CO_3^{--}, HCO_3^-, OH^- and H^+ ions and dissolved CO_2 gases in water decide the acidic or basic nature of water while the salts of ions like Ca^{++} and Mg^{++} in water makes it soft and hard. Water with high Na^+ and Cl^- concentration can make the water saline. Nitrate ions percolated from anthropogenic sources can become predominant major anion in groundwater. The excess fluoride concentration in ground water from fluoride bearing minerals may be related to the concentration of Ca^{++}, Na^+ and HCO_3^- ions present in ground water. The ranges and average values of the parameters analyzed in ground water samples collected from wells representing shallow aquifer are summarized below in Table-1

Table-1: Range and Average Values of Parameters in Ground Water.

Parameter	Range	Average
pH	7.8-8.7	8.25
EC (µS/cm at 25°C)	460-959	710
Total Alkalinity as $CaCO_3$ (mg/L)	120-190	155
TH as $CaCO_3$ (mg/L)	220-360	290
NO_3 (mg/L)	8-72	40
F (mg/L)	BDL	BDL

6.2.1 Distribution of pH

The overall range and average value of pH of the ground water samples indicates that the ground water in the PCMC industrial area is predominantly alkaline in nature. The pH values also indicates that the CO_2 dissolved in water is existing mainly in the form of HCO_3^- while it is also appearing as a CO_3^{--} in those samples where pH is more than 8.3. This is also clear from the concentration of HCO_3 and CO_3 ions in the ground water. Under the natural condition, the pH of ground water is usually found in the range of 6.5 to 8.5. However, low pH (<6.5) or high pH (>8.5) found in the ground water may be due to the availability or lack of CO_2 in environment in which the water exists. Sometimes, it may also be due to the percolation of strongly acidic or alkaline wastewater from anthropogenic sources to groundwater. The high values of pH i.e., > 8.5 was found in one out of 5 samples collected from the monitoring wells. The ground water from the monitoring well located at village Dudalgaon has indicated highest pH value of 8.7.

6.2.2 Distribution of Electrical Conductivity (EC)

The measurement of EC of water gives an idea about the ions concentration in the water. As the concentration of dissolved ions increases, the water becomes more conductive. EC and TDS are interrelated as mostly inorganic substances are dissolved in ground water. The TDS is computed as sum of ions concentration in ground water. It is also an important parameter to assess the quality of water. The distribution of EC in ground water in PCMC industrial area is shown in Plate-V. The perusal of Plate-V indicate that the EC value ranges from 750 to 900 µS/cm at 25^0C in major part of the area whereas in the central part of the industrial area it is observed above 900 µS/cm. This higher values of EC may be due to leaching of chlorides and sodium from industrial effluents/anthropogenic activities.

6.2.3 Distribution of Total Alkalinity

The total alkalinity of water is its acid neutralizing capacity and primarily a function of carbonate, bicarbonate and hydroxide content of water. It is expressed in terms of $CaCO_3$. In the ground water samples from monitoring wells, the alkalinity is mainly due to bicarbonate ions as most of the samples are having pH less than 8.3. The data on total alkalinity indicate that it is within desirable limit except one sample which has recorded pH more than desirable limit but within permissible limits.

6.2.4 Distribution of Total Hardness (TH)

The total hardness is the sum of calcium and magnesium concentration expressed in terms of $CaCO_3$ in mg/L The carbonate and bicarbonate salts of Ca and

Mg give temporary hardness to ground water while chloride and sulphate salts gives permanent hardness. The TH in the study area ranges from 220 to 360 mg/L and all the samples are within the maximum permissible limits of BIS Drinking Water Standards. The values of TH marginally above the desirable limit i.e. above 300mg/L may be attributed to the interaction/ inheritance of the constituents from basaltic aquifer material. The distribution of TH in ground water is given in Plate-VI.

6.2.5 Distribution of Nitrate (NO_3)

Under natural geochemical conditions, the nitrate rarely becomes a major ion in the ground water. But the nitrate content in the ground water more than 45 mg/L may be due to domestic waste, wastewater and sewage . The concentration of nitrate in the study area varies from 8 to 64 mg/L. 80% of samples have recorded nitrate concentration within desirable limits whereas 20% have shown concentration more than maximum permissible limits of BIS Drinking Water Standards

6.2.6 Distribution of Fluoride (F)

The range of concentration of fluoride in ground water the study area shows that the concentration in shallow basaltic aquifer is low and within desirable limits.

6.3 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 for drinking purpose. The overall classification of ground water samples indicate that the constituents are falling within desirable limit (<DL), in the range of desirable to maximum permissible limit (DL-MPL) except few which have shown the presence of nitrate above maximum permissible limit (MPL) for drinking water purpose as shown in Table-2.

The perusal of Table-2 shows that concentration of all the parameters are below Maximum Permissible Limits (MPL) of Drinking Water Standards. However 20% of samples are having the NO_3 concentration more than MPL. Overall, it is observed from the Table-2 that the potability of groundwater in the monitoring wells is mainly affected by NO_3 followed by TH.

Table-2: Classification of Ground Water Samples as per BIS Drinking Water Standards.

Parameters	Drinking water Standards (IS-10500-93)		Total No. of GW Samples	Samples with conc. <DL		Samples with conc. DL-MPL		Samples with conc.>MPL	
	DL	MPL		No.	%	No.	%	No.	%
pH	6.5-8.5	No relaxation	10	9	90	1	10	-	-
TA (mg/L)	200	600	10	10	100	-	-	-	-
TH (mg/L)	300	600	10	4	40	6	60	-	-
NO_3 (mg/L)	45	No relaxation	10	8	80	--		2	20
F (mg/L)	1.0	1.5	10	10	100	-	-	-	-

DL – Desirable Limits, MPL – Maximum Permissible Limits

6.4 Suitability of Ground Water for Irrigation Purpose

The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. The Electrical Conductivity (EC), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation. The parameter EC and RSC are considered and discussed below for evaluating suitability of ground water for irrigation purpose.

6.4.1 Electrical Conductivity (EC)

The amount of dissolved ions in the water is best represented by the parameter electrical conductivity. The classification of water for irrigation based on the EC values is as follows.

Low Salinity Water (EC: 100-250 µS/cm): This water can be used for irrigation with most crops on most soils with little likelihood that salinity will develop.

Medium Salinity Water (EC: 250 – 750 µS/cm): This water can be used if moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High Salinity Water (EC: 750 – 2250 µS/cm): This water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very High Salinity Water (EC: >2250 µS/cm): This water is not suitable for irrigation under ordinary condition. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops should be selected.

The classification of ground water samples collected from monitoring wells for irrigation purpose was carried out and given below in Table-3.

It is seen from the Table-3 that maximum number of samples fall under the category of medium and high salinity water; nearly 60% of samples fall under medium salinity water and 40% of samples in very high salinity water. This shows that the ground water should be used for irrigation with proper soil and crop management practices.

Table-3: Classification of Ground water for Irrigation based on EC values.

Type	**EC (µS/cm)**	**No. of Samples**	**% of Samples**
Low Salinity Water	<250	nil	nil
Medium Salinity Water	250-750	6	60
High Salinity Water	750-2250	4	40
Very High Salinity Water	>2250	nil	nil
Total		10	100

6.4.2 Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate (RSC) is considered to be superior to SAR as a measure of sodicity particularly at low salinity levels. Calcium reacts with bi-carbonate and precipitate as $CaCO_3$. Magnesium salt is more soluble and so there are fewer tendencies for it to precipitate. When calcium and magnesium are lost from the water, the proportion of sodium is increased resulting in the increase in sodium hazard. This hazard is evaluated in terms of RSC.

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

(Here, all the ionic concentrations in the above equation are expressed in meq/L).

The classification of ground water samples based on RSC values for its suitability for irrigation purpose is shown in Table-4.

Table-4: Classification of Ground water for Irrigation based on RSC values.

	RSC Value (meq/L)					
	<1.25		**1.25-2.50**		**>2.50**	
Quality →	**Good**		**Doubtful**		**Bad (Unsuitable)**	
Total no. of GW Samples	No. of Samples	% of Samples	No. of Samples	% of Samples	No. of Samples	% of Samples
10	10	100	-	-	-	-

From the Table-4, it is observed that 100% of the ground water samples show RSC values less than 1.25 meq/L indicating that the ground water is good for irrigation.

In order to compare the ground water quality of MIDC area with that of the area outside/upstream, water samples have also been collected from upstream part of the area. The comparison reveals that major chemical parameters are having more or less same concentration except the EC, which is higher in MIDC area

6.5 Heavy Metal Concentration

Total 10 nos of ground water samples from MIDC area as well as outside/upstream of MIDC were analyzed for heavy metal like Cu, Mn, Fe , Pb, Zn to see if it can aid in detecting in ground water pollution caused by effluents of Metal, Automobile and Electroplating industries.

The concentration of trace element is found much below the permissible limits (0.01mg/l). Hence it is concluded that pollution has not increased the concentration of trace elements. The results indicate that the ground water is largely free form heavy metal contamination as many of the analyzed trace metals were found in either below detectable limits (BDL) or within the desirable limits of BIS drinking water standards

(Annexure-III). However the very presence of heavy metal in ground water indicates the initiation of pollution in the area.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the hydrochemical study and major element chemistry of ground water in and around industrial clusters of Pimpri-Chinchawad MIDC area, the following conclusions are drawn and suitable recommendations are made to arrest and improve the ground water quality in the area.

7.1 Conclusions

1. The MIDC of Pimpri-Chinchawad situated in Pune district, has established adequate infrastructure facilities for providing suitable water for both industrial and domestic uses as well as effluent treatment and waste disposal mechanism is put in place. But due to inefficient functioning of Effluents Treatment Plants (ETP) and leakages at some locations combined with laxity on the part of industrial management, there are selectively susceptible areas for water contamination.

2. Pimpri- Chinchawad MIDC area of Pune is situated on the banks of Pavana and Indrayani Rivers, at an average altitude of 530 to 566m. above mean sea level

3. The area is underlain by the basaltic lava flows belonging to Deccan traps of Upper Cretaceous to Lower Eocene age and recent alluvium along the river banks .

4. Weathering is the important phenomena affecting water-bearing properties of basalt. Intensity of weathering is higher in these plain area. The depth of weathering is in general up to 5 m and maximum it is up to 15 m. The thickness of weathering and high permeability of rock formation allows quick movement of surface effluents contaminants into ground water.

5. The depth to water level ranges between 2 and 5 m bgl in major part of the areas in pre-monsoon and is less than 2 m in post-monsoon. The seasonal fluctuation of water levels is less than 2.0 m in the MIDC area. This hydrogeological scenario indicates stagnant ground water conditions in MIDC area, which is vulnerable for ground water pollution.

6. The physio-chemical and biological parameters viz. pH, COD, BOD, DO and total coliform, were analyzed by PCMC. The results of the studies indicate that surface water bodies are affected by pollution due to discharge of industrial and domestic effluents in nallah water, untreated sewage, ashanbhumi (cremation) waste, industrial wastewater etc. The average value of COD in surface water bodies is within the MPCB limit of 150 mg/l, while BOD is above the prescribed limit (MPCB limit) by 30 mg/l, it neither satisfies the requirement for agriculture nor the fishery & wild life propagation. Besides, excessive levels of total suspended solids (TSS) and total coliform beyond the permissible limit of human consumption the DO level is also recorded less than 2 mg/l which is below the minimum requirement for aquatic life.

7. The values of TH of ground water marginally above the desirable limit i.e. above 300mg/L observed in Sixty percent of samples are above permissible limits but fall within Maximum Permissible Limits category. This may be attributed to the interaction/ inheritance of the constituents from basaltic aquifer material.

8. The analysis of suitability of ground water for irrigation based on EC values indicate that 60% of samples fall under medium salinity water and 40% of samples in high salinity water. Therefore, the ground water from shallow aquifer should be used for irrigation with proper soil and crop management practices. However, Classification based on RSC , indicate that 100% of the ground water samples show RSC values less than 1.25 meq/L indicating that the ground water is good for irrigation.

9. The concentration of trace element in ground water is much below the permissible limits. Hence, pollution has not increased the concentration of trace elements. The ground water is largely free form heavy metal contamination as many of the analyzed trace metals were found in either below detectable limits (BDL) or within the desirable limits of BIS drinking water standards. However very presence of few heavy metals in ground water indicates the initiation of pollution in the area.
10. Majority of the analysed elements are well within the maximum permissible limits of BIS drinking water standards. The pH is in 10% of sample, total Hardness in 60% of samples are above desirable limits but within but within maximum permissible limits of drinking water standards of BIS. However NO_3 concentration is more than maximum permissible limits in 20% of samples.
11. The higher value of EC in MIDC area could be due to leakage of industrial effluents from discharge channels and their subsequent migration down to phreatic aquifers.
12. As the studied MIDCs have effluent treatment facility and arrangements to dispose-off the industrial wastes , there is limited scope for groundwater contamination. But in the process of effluent transportation leakages could be resulting in point source contamination damaging the shallow aquifer at local level. However since the ground water is not widely used for drinking purpose no adverse effect on human health is reported from these areas.

7.2 Recommendations

1. The possibility of ground water pollution to even greater extent exists as the underlying formation is quite receptive to pollutants leaching/percolating into the ground water. The shallow water level increases the possibility of greater pollution. Hence It is recommended that
    - Effluents generated from industries must be properly treated before its disposal by the industries in it should conform to the prescribed standards of EPR 1986.

- Leakage from pipelines carrying industrial waste must be prevented by doing regular checking and repair and effluent should be properly disposed.
- Major effluent generating industries that have primary effluent treatment facilities must maintain the pH level of their effluents to about 7.5 before disposing in to effluent sump.
- Disposal of solid wastes and effluents on roadside and local drainage and open field must be stopped immediately.
- The pH level of the effluent sumps must be maintained at least 7.5 before disposal.
- Ground water pollution should be monitored frequently in the industrial belt to identify pollution sources and to initiate corrective and regulatory actions through pollution control measures.

Annexure-I

Hydrogeological Details of Wells Inventoried in and around Pimpri Chinchwad MIDC Cluster Area.

Sl.No.	Location with lat-long	District	Type of well	Date of inventory	Location	M.P. (Magl)	Diameter	Depth	Depth of water level	Aquifer	Geological Horizon
1	**Nere(Marunji)** 73˚42´44″ 18˚36´48″	Pune	DW	4-9-2010	Near Dattwadi, besides Hinjwadi-nere road, 6km from Hinjewadi	1.20	4.30	8.00	5.30	Weathered Basalt	Deccan Basalt
2	**Ravet** 73˚44´30″ 18˚38´40″	Pune	DW	4-9-2010	In the field of Sh. Sontakke, near Malekar Wasti, 03km from Akurdy railway station	0.00	3.05	14	GL	Weathered Basalt	Deccan Basalt
3	**Rahatani** 73˚47´16″ 18˚36´17″	Pune	DW	4-9-2010	In the field of Sh. Nakhate, on Kalewadi-Rahatani-Pimpri road	1.20	7.60	18.00	6.10	Weathered Basalt	Deccan Basalt
4	**Chinchwad** 73˚48´08″ 18˚38´28″	Pune	DW	4-9-2010	In the premises of Ram Mandir, Mohan nagar-Telco road	0.15	9.50	5.27	GL	Weathered Basalt	Deccan Basalt
5	**Kasarwadi** 73˚49´20″ 18˚36´29″	Pune	DW	4-9-2010	5mS of M/s Harish brakeliners, north of Nasik phata	0.70	3.90	4.81	1.20	Weathered Basalt	Deccan Basalt
6	**Talwade** 73˚47´15″ 18˚40´47″	Pune	DW	4-9-2010	In the field of Sh. Bhalekar, near bhalekar chowk on Nigadi-Talwade road	0.50	6.50	12.00	0.90	Weathered Basalt	Deccan Basalt
7	**Chikhali** 73˚48´51″ 18˚41´01″	Pune	DW	4-9-2010	In the premises of Indraprastha mangal karyalaya in Indira nagar area	0.20	6.50	16.00	1.20	Weathered Basalt	Deccan Basalt
8	**Dudulgaon** 73˚50´05″ 18˚40´45″	Pune	DW	4-9-2010	Near culvert, opp. Gita bhagvat ashram, Alandi road	0.00	6.00	6.00	GL	Weathered Basalt	Deccan Basalt
9	**Moshi** 73˚52´22″ 18˚40´45″	Pune	DW	4-9-2010	In the field of Sasthe Patil, Bankar wasti	0.50	3.60	7.00	1.90	Weathered Basalt	Deccan Basalt
10	**Kalas** 73˚52´22″ 18˚40´45″	Pune	DW	4-9-2010	In the premises of Sh. Dhapate's house, Vishrantwadi-Kalas road	1.3	3.5	8.00	4.90	Weathered Basalt	Deccan Basalt

Annexure-II

Pre-Monsoon and Post-Monsoon Water Level Data of Observation Wells Pimpri Chinchwad MIDC Cluster Area

Sl.No.	Location	Depth to Water Level in May 2011 (m.bgl) (Pre-Monsoon)	Depth to Water Level in Nov. 2011 (m.bgl) (Post-Monsoon)	Seasonal Fluctuation in Water Level (May-Nov. 2011) (m.bgl)
1	**Nere(Marunji)**	3.70	3.80	-0.01
2	**Ravet**	4.18	2.64	4.54
3	**Rahatani**	6.75	4.34	2.41
4	**Chinchwad**	2.20	1.10	1.10
5	**Kasarwadi**	3.56	3.40	0.16
6	**Talwade**	2.78	1.95	0.83
7	**Chikhali**	4.10	1.20	2.99
8	**Moshi**	6.35	1.45	4.90
9	**Dudulgaon**	6.52	2.46	4.06
10	**Kalas**	6.85	3.15	3.70

Annexure-III

Results of Chemical Analysis of Ground Water Samples of Pimpri Chinchwad MIDC Cluster Area.

Sl. No.	Location	pH	EC	TH	TA	NO_3	F	RSC	Cu	Mn	Pb	Fe	Zn
1	**Nere(Marunji)**	8	660	220	-	30	BDL	1.2	BDL	BDL	BDL	BDL	BDL
2	**Ravet**	8.1	600	360	190	18	BDL	-3.4	BDL	BDL	BDL	BDL	BDL
3	**Rahatani**	8.1	630	350	-	27	BDL	-1.2	BDL	BDL	BDL	BDL	BDL
4	**Chinchwad**	7.8	959	295	-	08	0.37	-	BDL	BDL	BDL	BDL	BDL
5	**Kasarwadi**	8.1	880	290	-	19	BDL	1.2	BDL	BDL	BDL	BDL	BDL
6	**Talwade**	8	770	310	160	64	BDL	-5.2	BDL	BDL	BDL	BDL	BDL
7	**Chikhali**	7.9	850	320	160	33	BDL	-4.2	BDL	0.02	0.02	BDL	0.098
8	**Moshi**	8.2	670	320	120	36	BDL	-4.2	BDL	BDL	BDL	BDL	BDL
9	**Dudulgaon**	8.7	460	300	140	72	BDL	-3.2	BDL	BDL	BDL	BDL	BDL
10	**Kalas**	8.3	590	250	-	12	BDL	0.4	BDL	BDL	BDL	BDL	BDL

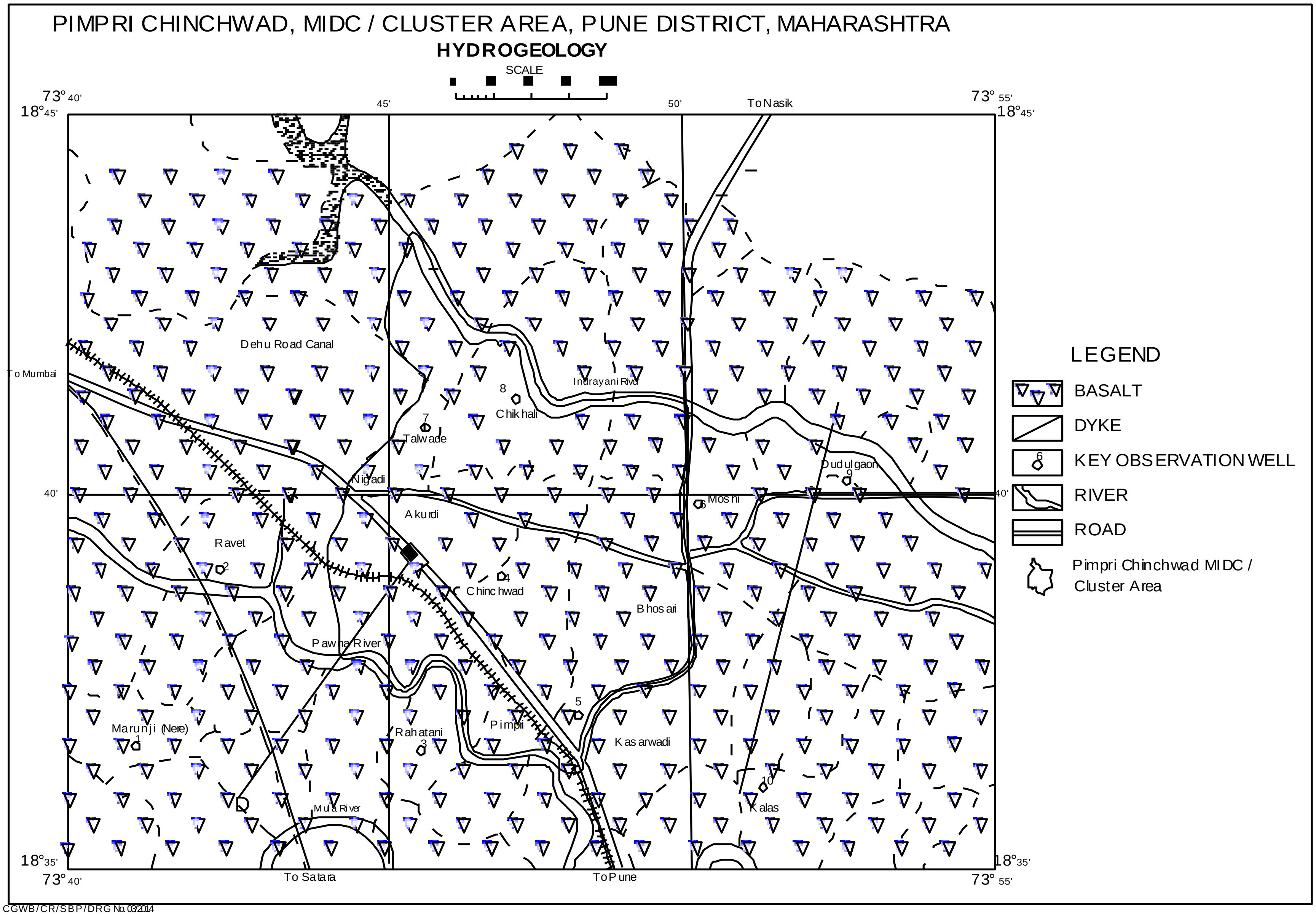
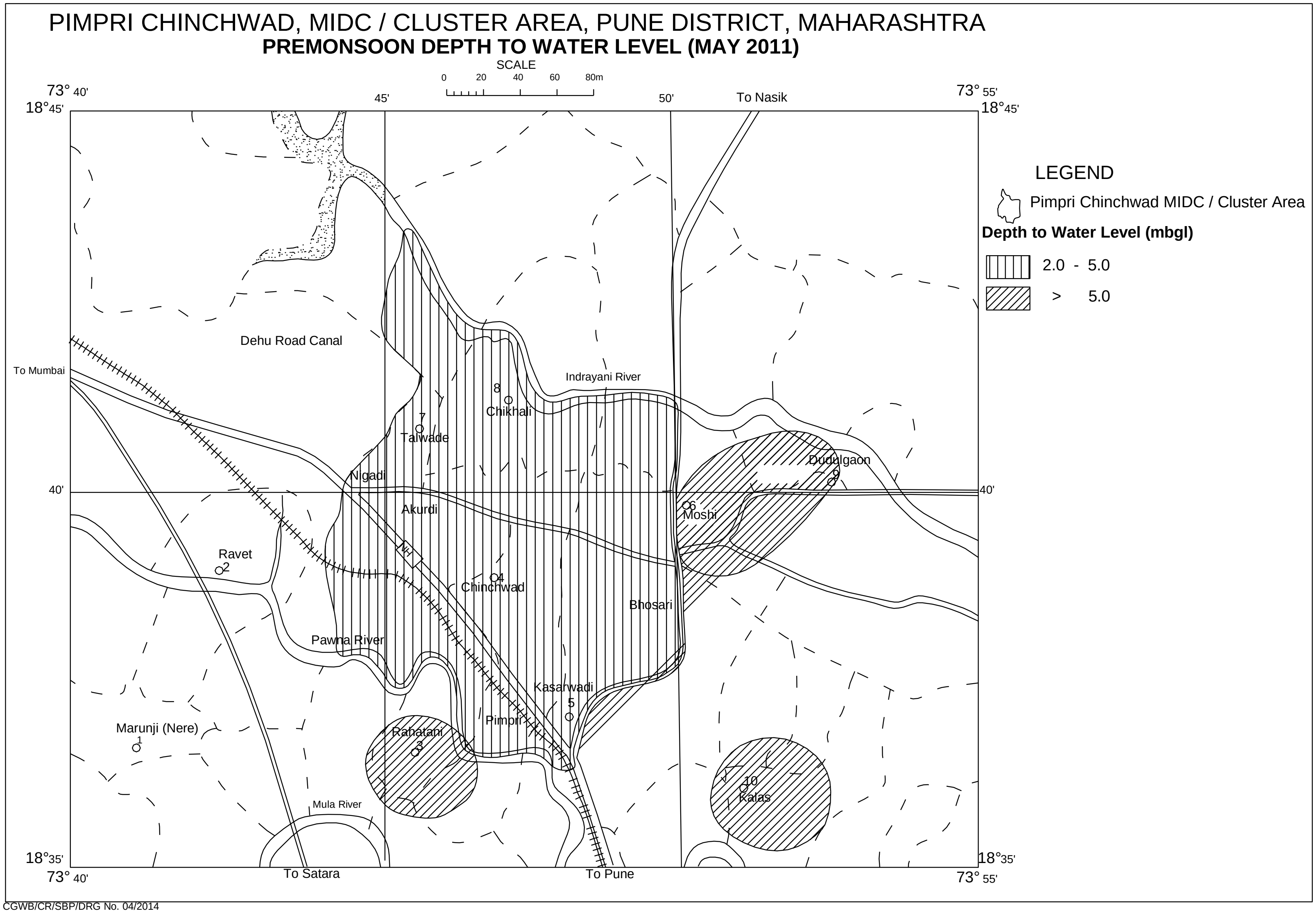

PIMPRI CHINCHWAD, MIDC / CLUSTER AREA, PUNE DISTRICT, MAHARASHTRA
HYDROGEOLOGY
SCALE
73° 40'
18° 45'
45'
50'
To Nasik
73° 55'
18° 45'
To Mumbai
40'
Dehu Road Canal
Indrayani River
Chikhali
Talwade
Nigadi
Akurdi
Moshi
Dudulgaon
Ravet
Chinchwad
Bhosari
Pawna River
Pimpri
Rahatani
Kasarwadi
Marunji (Nere)
Mula River
Kalas
18° 35'
73° 40'
To Satara
To Pune
73° 55'
LEGEND
BASALT
DYKE
KEY OBSERVATION WELL
RIVER
ROAD
Pimpri Chinchwad MIDC / Cluster Area
CGWB/CR/SBP/DRG No. 03/2014

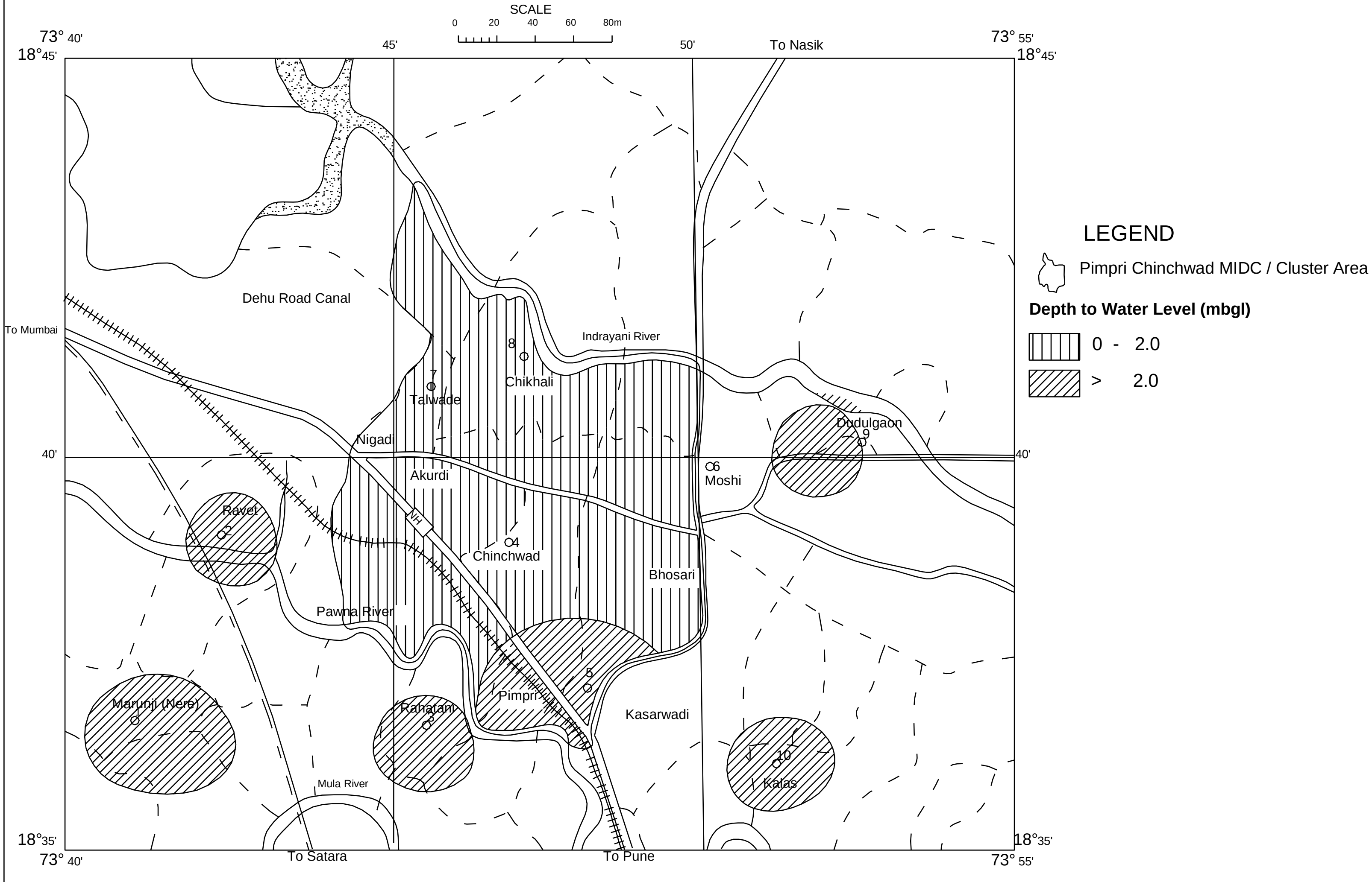
PLATE - II



CGWB/CR/SBP/DRG No. 04/2014

PIMPRI CHINCHWAD, MIDC / CLUSTER AREA, PUNE DISTRICT, MAHARASHTRA

POST MONSOON DEPTH TO WATER LEVEL (NOV. 2011)

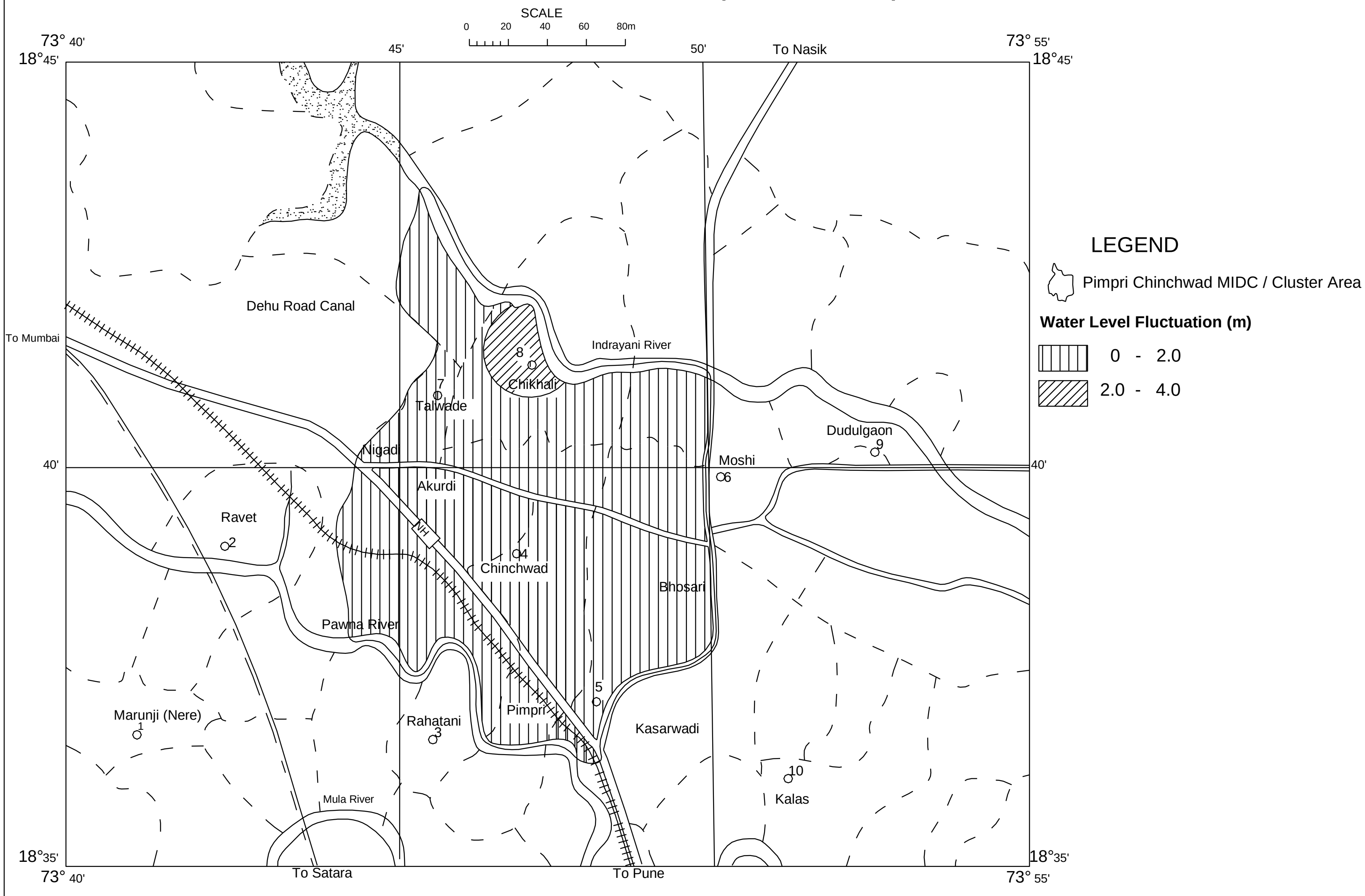


CGWB/CR/SBP/DRG No. 05/2014

PLATE - IV

PIMPRI CHINCHWAD, MIDC / CLUSTER AREA, PUNE DISTRICT, MAHARASHTRA

SEASONAL WATER LEVEL, FLUCTUATION (MAY- NOV 2011)



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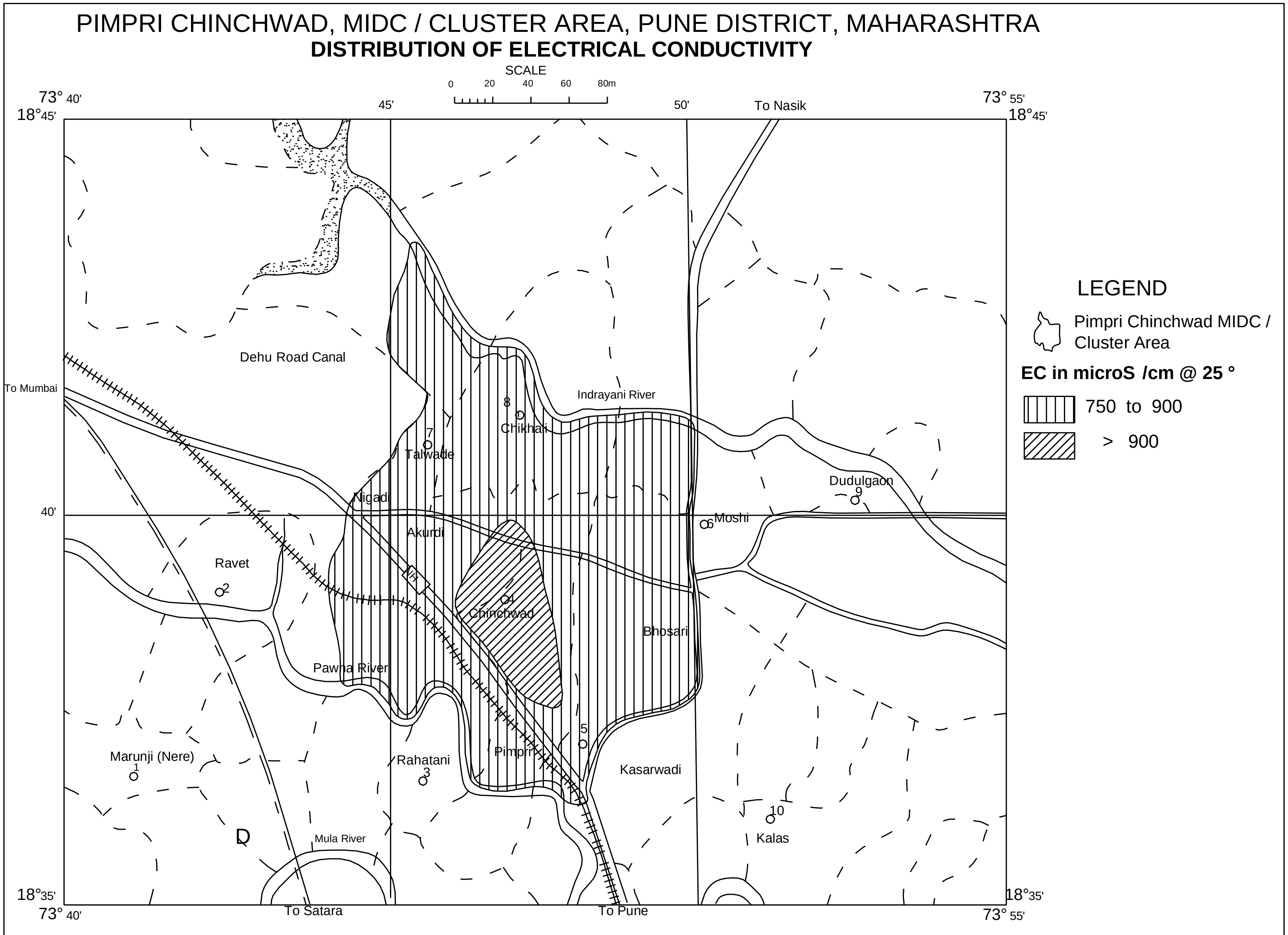

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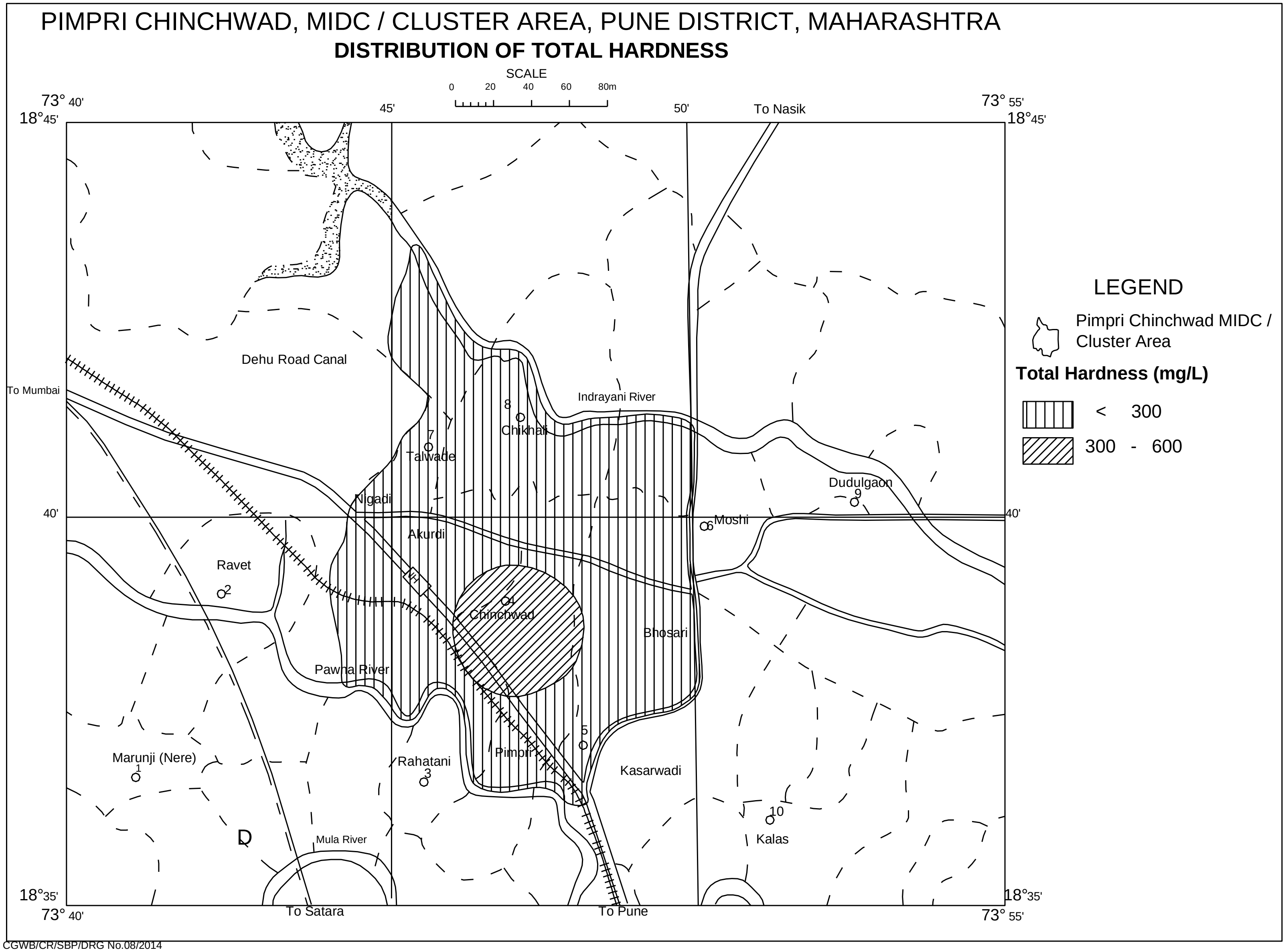
PIMPRI CHINCHWAD, MIDC / CLUSTER AREA, PUNE DISTRICT, MAHARASHTRA
DISTRIBUTION OF TOTAL HARDNESS
SCALE
0 20 40 60 80m
73° 40'
18°45'
45'
50'
To Nasik
73° 55'
18°45'
To Mumbai
Dehu Road Canal
Indrayani River
Chikhali
Talwade
Nigadi
Akurdi
Moshi
Dudulgaon
Ravet
Chinchwad
Bhosari
Pawna River
Marunji (Nere)
Rahatani
Pimpri
Kasarwadi
Kalas
Mula River
40'
40'
18°35'
73° 40'
To Satara
To Pune
18°35'
73° 55'
LEGEND
Pimpri Chinchwad MIDC / Cluster Area
Total Hardness (mg/L)
< 300
300 - 600
CGWB/CR/SBP/DRG No.08/2014