कार्यालयीन उपयोग हेतु
For Official Use Only
1841/POL/2014

भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूमीजल बोर्ड

GOVT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

GROUND WATER POLLUTION STUDY IN NASHIK MIDC AREA/CLUSTER, NASHIK DISTRICT, MAHARASHTRA

नासिक MIDC क्षेत्र / समूह, नासिक जिले, महाराष्ट्र में भूजल प्रदूषण का अध्ययन

(AAP 2010-11)

By
S.D. WAGHMARE
Asst. Hydrogeologist
T.R. MATHURE
Officer Surveyor

द्वारा
एस॰ डी॰ वाघमारे
सहयाक भूजल वैज्ञाज्ञानिक
टी. आर. माथुरे
सर्वेक्षक अधिकारी

मध्य क्षेत्र / CENTRAL REGION
नागपुर / NAGPUR
2014

GROUND WATER POLLUTION STUDY IN NASHIK MIDC AREA/CLUSTER, NASHIK DISTRICT, MAHARASHTRA.

CONTENTS

GROUND WATER POLLUTION IN NASHIK MIDC AREA/CLUSTER, NASHIK DISTRICT, MAHARASHTRA.

1.0 INTRODUCTION:

In pursuance of CHQ, letter no 34/CGWB/M (SAM)/WQAA/2010 dated 1/9/2010 pertaining to status and monitoring the ground water pollution in the Industrial areas /clusters identified by CPCB in Maharashtra region, the ground water samples were collected in November-2011 from MIDC area of Nashik. The samples were analyzed for inorganic ions and trace metal ions at Chemical Lab of CGWB, CR, Nagpur.

The Central Pollution control Board (CPCB) in association with Indian Institute of Technology (IIT), New Delhi have carried out an environmental assessment of Industrial clusters across the country based on Comprehensive Environmental Pollution Index (CEPI) with the aim of indentifying pollution industrial cluster and prioritising planning needs for intervention to improve the quality of environment in these industrial clusters and the nation as a whole. In all 88 industrial clusters in the country have been assessed by CPCB and the area of MIDC Nashik is one of them.

1.1 The Sampling Area

Nasik District is situated in north western part of Maharashtra. It lies between 19°35’ and 20°50’ north latitude and between 73°16’ and 74°56’ east longitude and falls in parts of Survey of India degree sheets 46-H, 46-L and 47-E and 47-I. The district has a geographical area of 15530 sq. km. It is surrounded by Dhule district in the north, Dangs and Surat district of Gujarat State in the northwest, Jalgaon in the east and northeast, Ahmednagar in the south, Aurangabad in the southeast and Thane in the west and southwest.

The area taken up for ground water pollution study covering MIDC area of Nashik City, Nashik District. The study area is located 7 Kms North West of Nashik city on Nashik-Trimbak road. The area covers about 20 sq. km. and with North latitude 19°59'32.45" and 20°00’35” and East longitude 73°42'40" and 73°45'15". The locations at Chikhli Naka, Someshwar temple, Hanuman ghat, Amardham, and Nashik MIDC area constitute the sampling area. The main industries located in the area are Pharmaceuticals, Automobile, Distilleries, Metal, Aluminium, Metal engineering, Tyre, Biotech, Pesticides etc.

1.2 Climate and Rainfall

The climate of the area is characterized, by general dryness throughout the year except during the south-west monsoon season. The winter season is from December to about the middle of February followed by summer season which last up to May. June to September is the south-west monsoon season, whereas October and November constitute the post-monsoon season. The maximum temperature in summer is 42.5°C and minimum temperature in winter is less than 5.0°C. Relative humidity ranges from 43% to 62%. The average normal annual rainfall of Nashik is 930 mm.

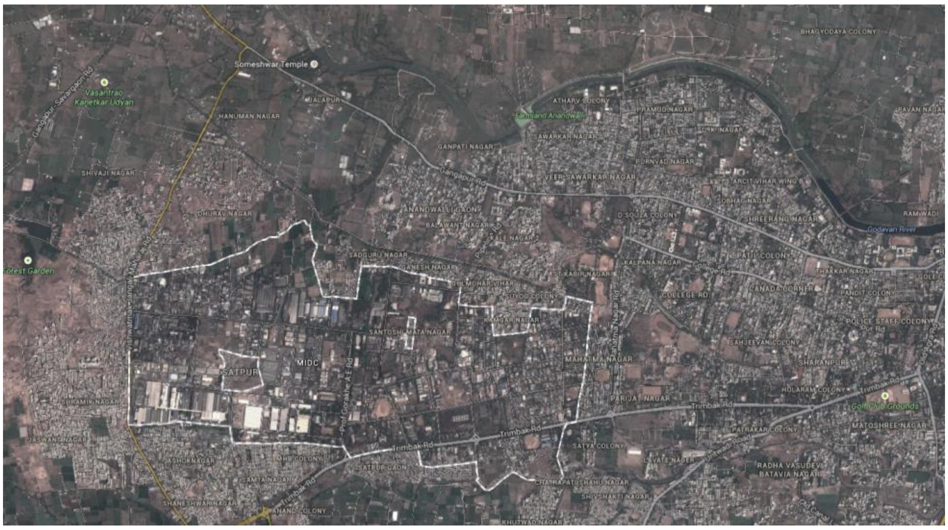

Figure-1: Location of Nashik MIDC Area / Cluster

1.3 Geomorphology:

The area forms part of Deccan Plateau and falls under Godavari basin. The area is drained by Godavari River and its tributaries. The elevation in the area ranges from 631 to 580 m amsl, the natural gradient is towards Godavari River, which flows from west to east in the northern part of the MIDC area. The local nala from MIDC area merges with the Godavari River near Someshwar temple.

2.0 Ground Water Regime

2.1 Hydrogeology

The entire area of the district 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 banks of Godavari River flowing in the area.

2.1.1 Hard Rock (Deccan Trap Basalt)

Basaltic lava flows occupies about 90% of the sampling area. These flows are normally horizontally disposed over a wide stretch and give rise to table land type of topography also known a plateau. These flows occur in layered sequences and represented by massive unit at the bottom and vesicular unit at the top of the flow. These flows are separated from each other by marker bed known as ‘bole bed’.

2.2 Water Level Scenario

The ground water in Deccan Trap Basalt occurs mostly in the upper weathered and fractured parts down to 20-25 m depth. At places potential zones are encountered at deeper levels in the form of fractures and inter-flow zones. The upper weathered and fractured parts form phreatic aquifer and ground water occurs under water table (unconfined) conditions. At deeper levels, the ground water occurs under semi-confined to confined conditions. The yield of dugwells tapping upper phreatic aquifer down to the depth of 12 to 15 m bgl ranges between 45 to 90 m^3/day depending upon the local hydrogeological conditions. Borewells drilled down to 70 m depth, tapping weathered and vesicular basalt are found to yield 18 to 68 m^3/day. The discharge of Peizometers ranges from 0.14 to 1.73 as seen from CGWB data.

3.0 Hydrochemistry

3.1 Sampling

Nine water samples were collected during field investigation. 2 water samples were collected from shallow aquifer i.e., dug wells, 1 samples was collected deeper aquifer i.e., hand pump and 6 water samples were collected from surface water sources. The details about the locations and sources of the samples are given in Table 1

Table 1: The details of the locations and results of the samples in MIDC area, Nashik district.

Locations	Source	pH	EC	TDS	TA	TH	NO_3	F	RSC
Shomeshwar Temple	SW	8.8	380	247	200	410	5	BDL	-4.2
Chikli Naka	SW	8.2	850	553	140	410	28	BDL	-5.4
Hanuman Ghat	SW	8.6	590	384	190	680	8	BDL	-9.8
Nashik	SW	8.7	580	377	240	430	13	BDL	-3.8
Amar Dham	SW	8.7	540	351	210	290	12	BDL	-1.6
Nashik	SW	8.5	610	397	260	230	12	BDL	0.6
Nashik	DW	8.0	2160	1404	380	1050	30	BDL	-13.4
Nashik	DW	7.8	2380	1547	280	770	79	BDL	-9.8
Nashik	HP	8.0	1160	754	240	300	0.4	BDL	-1.2

3.2 Analysis:

Inorganic constituents like Total Alkalinity (TA), Cl, NO_3, F, and Total Hardness (TH), are estimated along with physical parameters like pH and Electrical conductivity (EC) to study the water quality in relation to aquifer (Table-I). Analysis of trace metals ions like Pb, Mn, Cu, Zn and Fe were also carried out to study contamination of ground water by trace elements. The major and minor constituents were determined in the laboratory according to the standard methods given by APHA, using instruments like pH-meter, EC meter, flame photometer and UV-VIS spectrophotometer. Trace metal analysis were carried out by using Atomic Absorption Spectrophotometer.

The chemical characteristics of ground water in the area under investigation are presented in Table 1 and explained below.

3.2.1 Inorganic Constituents

3.2.1.1 pH:

The pH of ground water generally lies in the range of 6-8 and may be altered due to contamination of groundwater by acidic or alkaline effluents. In the study area the pH of ground water lies in the range of 7.8 to 8.8. All the samples in the vicinity of MIDC area have pH more than 7, showing alkaline range. The pH values of samples collected from surface water range from 8.2 to 8.7.

3.2.1.2 Electrical Conductivity (EC) and Total Dissolved Solids (TDS):

The determination of EC and TDS were carried out to know about the extent of mineralisation of ground water in the study area. In basalts, the average EC and TDS values are generally 1000 µS/cm at 25^0C and 570 mg/l respectively.

In the area under investigation, the EC values of ground water are in the range of 1160 to 2380 µS/cm at 25°C. The two samples are having EC values more than 2000 µS/cm indicating that there is substantial deviation from background values. The EC values of the water samples collected from surface water in the MIDC area lies in the range of 380-850 µS/cm.

3.2.1.3 Nitrate (NO_3):

The nitrate concentration lies in the range of 5 to 28 mg/L in surface water while in ground water it is in the range of 0.4 to 79 mg/L. The higher value is recorded in the dug well of town area where ground water is susceptible to pollution due to sewage waste and garbage.

3.2.1.4 Total Alkalinity (TA):

In the area under investigation, Total Alkalinity in ground water lies in the range of 240 to 380 mg/l while in surface water it is in the range of 140 to 260 mg/l.

3.2.1.5 Fluoride (F):

In the study area, the fluoride content in ground water and surface water is below detectable limit.

3.2.1.6 Total Hardness (TH):

In the area under investigation, Total Hardness in ground water lies in the range of 300 to 1050 mg/l while in surface water it ranges from 90 to 680 mg/l.

3.2.2 Trace Metal Ions

Trace elements in natural or contaminated ground water with the exception of Iron almost invariably occur at concentrations well below 1 mg/l. Concentrations are low because of constraints imposed by solubility of minerals or amorphous substances and adsorption on clay minerals or on hydrous oxide of iron and magnesium. Isomorphous substitution or co-precipitation with minerals or amorphous substitution or co-precipitation with minerals or amorphous solids can also be important as far as the occurrence of trace elements in natural water is concerned. The solubility of cationic trace elements increases as pH decreases particularly at pH < 5.

In the area under investigation, 9 water samples were analyzed for trace elements like Mn Pb, Cu, Zn and Fe and the analysis results are given in Table-2. The results of the analysis of trace elements are discussed below.

Table 2: Results of the analysis of trace elements in MIDC area, Nashik District.

Locations	Type of well	Cu	Mn	Fe	Pb	Zn
Shomeshwar Temple	SW	BDL	0.053	0.189	0.06	BDL
Chikli Naka	SW	BDL	0.678	1.733	0.089	0.0712
Hanuman Ghat	SW	BDL	0.155	1.17	0.086	0.032
Nashik	SW	BDL	0.144	0.026	0.067	0.017
Amar Dham	SW	BDL	0.126	0.024	0.059	0.013
Nashik	SW	BDL	0.152	BDL	0.031	BDL
Nashik	DW	BDL	11.66	0.255	0.061	BDL
Nashik	DW	BDL	0.299	0.034	0.061	BDL
Nashik	HP	0.064	0.366	7.69	BDL	0.615

Here, BDL- Below Detectible Level

3.2.2.1 Manganese (Mn):

The major forms of Manganese in nature are oxides, silicates and carbonates. It is widely distributed in soil and an essential plant micronutrient element in plant metabolism and is expected that the organic circulation of Manganese can influence its occurrence in natural water. The sugarcane plant which is used as raw material in sugar industry may be possible source of Mn in ground water as the effluent generated from sugar and allied industries contains high amount of Mn. The desirable limit of Mn in drinking water is 0.1 mg/L and maximum permissible limit is 0.3 mg/L as per BIS standard (2012) for drinking water.

The concentration of Manganese in the ground water of study area was found to be in the range of 0.299 to 11.66 mg/l. In surface water the concentration of Manganese found in the range of 0.053 to 0.678 mg/l.

3.2.2.2 Iron (Fe):

Iron in ground water generally exists as Fe(II) but may oxidised to Fe(III) when ground water is under aerobic condition.

On land, major sources of Iron are the effluents of industries related with the manufacture of Iron or Steel and units in which Iron is one of the raw materials. Despite of heavy discharge of Iron in the atmosphere and land, solubility controls restrict migration of the Iron to the saturated zone.

In the study area of MIDC, the iron content in ground water samples is in the range of 0.034 to 7.69 mg/L. In surface water the concentration of Iron was found in the range of BDL to 1.733 mg/L.

3.2.2.3 Lead (Pb):

The natural lead content of lake and river water worldwide is in the range of 0.001 to 0.01. Lead content of ground water is generally low due to solubility control and capacity of soils to absorb lead. The higher values of lead have been found where the contamination has occurred particularly from industrial sources. The chemical analysis results of ground water from MIDC indicate that the lead content is in the range of BDL to 0.061 mg/l. In surface water the concentration of Lead was found in the range of 0.031 to 0.089 mg/L.

3.2.2.4 Copper (Cu):

The copper found in ground water of MIDC study area varies from BDL to 0.064 mg/L and in surface water it is below detectable limit. This is also essential micronutrient and very likely to come through the spent wash of distillery. The maximum concentration of 0.064 mg/L is estimated in the hand pump located in the vicinity of MIDC area.

3.2.2.5 Zinc (Zn):

The zinc content in MIDC study area varies from BDL to 0.0712mg/L. In the ground water samples the Zinc concentration was ranging from BDL to 0.615 mg/L.

4.0 Mechanism of Ground Water Pollution:

The ground water pollution mechanism is different from surface water pollution and takes more time for reactions in top soil, unsaturated and saturated zones. The untreated and partially treated effluents wastes in industrial area is discharged in small channels, low lying areas and pits which come in contact with surface and ground water and causes deterioration of water quality.

In unsaturated zone, the pollutants travel primarily vertically downwards and small amount takes horizontal displacement. Here the pollutants movement is mainly controlled by relative portion of active pore space, moisture content and climate of the area. As the solute moves through the zone of aeration it tends to slow dispersion and take considerable time to percolate. During the travel, substantial quantity of elements retain in soil profile, held up in clays or voids of aquifer media due to chemical reactions like ion exchange, dilution, precipitation, oxidation, reduction, absorption and mechanical filtration. The balance part moves in aqueous solution and reaches to saturated zone.

Pollutants in saturated zone usually spreads out laterally, floating on the top of aquifer and moves in the ground water flow direction with same velocity, mechanical dispersion, molecular diffusion and density difference plays a role in attenuation of contaminants to different degrees by various processes.

5.0 Suitability of Ground Water for Drinking and Domestic Purpose

The suitability of ground water for different uses like drinking and irrigation purpose is decided based on the standards prescribed for these uses and is dealt in detail in the following paragraphs.

5.1 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. The classification of ground water samples was carried out based on the Desirable Limit (DL) and Maximum Permissible Limits (MPL) as given by BIS for drinking water in IS-10500-2012 standards for the parameters viz., TDS, TH, Ca, Mg, Cl, SO_4 and NO_3 is given in Table-3.

Table 3: Classification of Ground Water Samples based on BIS Drinking Water Standards (IS-10500-2012, Second Revision)

Parameters	DL	MPL	No of Samples	Samples with conc. DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
pH	6.5-8.5	No relaxation	DW-2 HP-1	DW-NIL HP- NIL	DW-2 HP-1	DW-Nil HP-Nil
	Total		**03**	**Nil**	**3 (100%)**	**Nil**
TDS (mg/L)	500	2000	DW-2 HP-1	DW-NIL HP- NIL	DW-2 HP-1	DW-NIL HP- NIL
	Total		**03**	**Nil**	**3 (100%)**	**Nil**
TH (mg/L)	200	600	DW-2 HP-1	DW-NIL HP- NIL	DW-0 HP-1	DW-2 HP-0
	Total		**03**	**Nil**	**1 (33 %)**	**2 (67 %)**
TA (mg/L)	200	600	DW-2 HP-1	DW-NIL HP- NIL	DW-2 HP-1	DW-NIL HP- NIL
	Total		**03**	**Nil**	**3 (100%)**	**Nil**
NO_3 (mg/L)	45	No relaxation	DW-2 HP-1	DW-1 HP-1	NA	DW-1 HP- NIL
	Total		**03**	**2 (67%)**	**NA**	**1 (33%)**
F (mg/L)	1.0	1.5	DW-2 HP-1	DW-2 HP-1	DW-NIL HP- NIL	DW-NIL HP- NIL
			03	**3 (100%)**	**Nil**	**Nil**
Fe(mg/L)	0.3	No relaxation	DW-2 HP-1	DW-2 HP-0	DW-NIL HP- NIL	DW-0 HP-1
			03	**2 (67%)**	**Nil**	**1(33%)**
Pb (mg/L)	0.05	No relaxation	DW-2 HP-1	DW-0 HP-1	DW-NIL HP- NIL	DW-2 HP-0
			03	**1 (33 %)**	**Nil**	**2 (67%)**
Zn (mg/L)	5	15	DW-2 HP-1	DW-2 HP-1	DW-NIL HP- NIL	DW-NIL HP- NIL
			03	**03(100%)**	**Nil**	**Nil**
Cu (mg/L)	0.05	1.5	DW-2 HP-1	DW-2 HP-0	DW-0 HP-1	DW-NIL HP- NIL
			03	**02 (67%)**	**01(33%)**	**Nil**
Mn (mg/L)	0.1	0.3	DW-2 HP-1	DW-NIL HP- NIL	DW-1 HP-0	DW-1 HP-1
			03	**Nil**	**1 (33%)**	**2 (67%)**

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

The perusal of Table-3 reveals that concentration of pH, TDS, TA, is above desirable limit but below maximum permissible limit in most of the cases. However, the concentration of TH is found more the MPL in 67% ground water samples causing water hardness and the concentration of nitrate is also found more than MPL in 33% samples indicating high influence of anthropogenic activity in the vicinity of the wells, causing nitrate contamination.

In trace metals, the concentrations of Fe and Mn in 33% and Pb in 67% ground water samples are found beyond the maximum permissible limit while the Zinc and Copper contents are within permissible limit. Such presence of trace metal ions in the ground water system indicates that pollution has already initiated in the area mainly due to industrial activities.

5.2 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. Electrical Conductivity (EC) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation.

5.2.1 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 was carried out for irrigation purpose and given in **Table-4**. It is observed from the **Table-4** that maximum number of samples (67%) falls under the category of very high salinity water while nearly 33% of samples fall in high salinity water category.

Table-4: Classification of Ground Water for Irrigation based on EC.

Type	**EC (µS/cm)**	**No. of Samples**	**% of Samples**
Low Salinity Water	<250	Nil	Nil
Medium Salinity Water	250-750	Nil	Nil
High Salinity Water	750-2250	2	33
Very High Salinity Water	>2250	1	67
Total		**3**	**100**

5.2.2 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. The classification of ground water samples based on RSC values for its suitability for irrigation purpose is given in Table-5.

The Table-5 shows that, all the samples have RSC values below 1.25 indicating that the possibility of sodium hazard is low if the water is used for irrigation purpose. Overall, the ground water quality in the wells monitored is good and suitable for irrigation purpose and there is a less possibility of developing sodium hazard.

Table-5: Classification of Ground and Surface Water for Irrigation based on RSC.

RSC	**<1.25**		**1.25-2.50**		**>2.50**	
Category	Good		Doubtful		Unsuitable	
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples	%
3- GW **6-SW**	**9**	**100%**	**-**	**-**	**-**	**-**

5.3 Suitability of Surface Water

The suitability of surface water for drinking, irrigation and industrial purpose is determined keeping in view of the effects of various chemical constituents in water on the agriculture, public water supply scheme, etc. To assess the surface water quality and pollution, the standards prescribed by both Environmental (Protection) Rules, 1986 and MPCB, A-II were used as none of them covers all the parameters. The MPCB, A-II standards were considered as the said area falls under the catchment of Godavari River, which is classified as A-II class river.

Table 5: Classification of surface water (SW) Samples based on general standards for discharge of environmental pollutants as per environmental (Protection) Rules 1986.

Parameter	**Prescribed Standards Used**		**No. & % of samples as per EPR, 1986**		**No. & % of samples as per MPCB, A-II**	
	Environmental (Protection) Rule, 1986	**MPCB, A-II**	**Below limit**	**Above limit**	**Below limit**	**Above limit**
pH	NA	6.5 to 8.5	NA	NA	2 (33%)	4 (67%)
TDS (mg/L)	NA	1500	NA	NA	6 (100%)	Nil
NO_3 (mg/L)	NA	45	NA	NA	6 (100%)	Nil
F (mg/L)	NA	1.5	NA	NA	6 (100%)	Nil
Fe (mg/L)	3.00	5.00	6 (100%)	Nil	6 (100%)	Nil
Pb	0.10	0.10	6 (100%)	Nil	6 (100%)	Nil
Zn (mg/L)	5.00	1.50	6 (100%)	Nil	6 (100%)	Nil
Cu (mg/L)	3.00	1.50	6 (100%)	Nil	6 (100%)	Nil
Mn (mg/L)	2.00	3.00	6 (100%)	Nil	6 (100%)	Nil

The perusal of Table 5 reveals that the concentration of pH is above permissible limit in

67% of surface water samples, whereas TDS, NO_3, F are within permissible limits prescribed under MPCB, A-II standards. In case of trace metal ions viz., Fe, Pb, Zn, Cu and Mn the concentrations are within the acceptable limit as prescribed by Environmental (Protection) Rules 1986 and MPCB, A-II standards in all the surface water samples.

Therefore, it can be concluded that surface water quality is affected by high pH. However, as compared to surface water quality the ground water quality in major part of the study area is affected by industrial and anthropogenic pollution. The ground water of area is not suitable for drinking purpose as TH, NO_3, Fe, Pb and Mn concentrations are observed above MPL prescribed by BIS, 2012.

6.0 Conclusions

Different types of industries are located in the study area of Nashik MIDC. Overall 9 water samples were collected during field investigation. 2 water samples were collected from shallow aquifer i.e., dug wells, 1 sample was collected from deeper aquifer i.e., hand pump and 6 water samples were collected from surface water sources. On the basis of Chemical analysis of water samples significant findings are highlighted below:

1. In the study area the pH of ground water lies in the range of 7.8 to 8.8. All the samples in the vicinity of MIDC area have pH more than 7, showing alkaline range. The pH values of samples collected from surface water range from 8.2 to 8.7.
2. The EC values of ground water are in the range of 1160 to 2380 µS/cm at 25°C. The two samples are having EC values more than 2000 µS/cm indicating that there is substantial deviation from background values. The EC values of the water samples collected from surface water in the MIDC area lies in the range of 380-850 µS/cm, indicating that pollution intensity is low in the streams/rivers as compared to ground water.
3. The nitrate concentration lies in the range of 5 to 28 mg/L in surface water while in ground water it is in the range of 0.4 to 79 mg/L. The higher value is recorded in the dug well of town area where ground water is susceptible to anthropogenic pollution due to the poor drainage situation of the town and improper disposal of sewage and solid waste.
4. Total Alkalinity in ground water lies in the range of 240 to 380 mg/l while in surface water it is in the range of 140 to 260 mg/l.
5. Fluoride content in ground water is below detectable limit.
6. Total Hardness in ground water lies in the range of 300 to 1050 mg/l while in surface water it ranges from 90 to 680 mg/l.
7. The concentration of Manganese in the ground water of study area was found to be in the range of 0.299 to 11.66 mg/l. In surface water the concentration of Manganese found in the range of 0.053 to 0.678 mg/l.
8. In the study area of MIDC, the iron content in ground water samples is in the range of 0.034 to 7.69 mg/L. In surface water the concentration of Iron was found in the range of BDL to 1.733 mg/L.
9. The chemical analysis results of ground water from MIDC indicate that the lead content is in the range of BDL to 0.061 mg/l. In surface water the concentration of Lead was found in the range of 0.031 to 0.089 mg/L.
10. The copper found in ground water of MIDC study area varies from BDL to 0.064 mg/L and

in surface water it is below detectable limit. The maximum concentration of 0.064 mg/L was recorded in the hand pump located in the vicinity of MIDC area.

- The zinc content in MIDC study area varies from BDL to 0.0712mg/L. In the ground water samples the Zinc concentration was ranging from BDL to 0.615 mg/L.
- The concentration of inorganic ions and trace metal ions observed in ground water samples when compared with drinking water standards of BIS (2012) indicated that:
    - The concentration of TH is found more the MPL in 67% ground water samples causing water hardness and the concentration of nitrate is also found more than MPL in 33% samples indicating high influence of anthropogenic activity in the vicinity of the wells, causing nitrate contamination.
    - In trace metals, the concentrations of Fe and Mn in 33% and Pb in 67% ground water samples are beyond the maximum permissible limit while the Zinc and Copper contents are within permissible limit. The mere presence of trace metal ions in the ground water system indicates that pollution has already initiated in the area and the industrial activities are responsible for such higher concentration of trace metal ions in ground water

11. The concentration of inorganic ions and trace metal ions observed in surface water samples when compared with both Environmental (Protection) Rules, 1986 and MPCB, A-II indicated that:
    - The concentration of pH is above permissible limit in 67% of surface water samples, whereas TDS, NO_3, F are within permissible limits prescribed under MPCB, A-II standards. In case of trace metal ions viz., Fe, Pb, Zn, Cu and Mn the concentrations are within the acceptable limit of both Environmental (Protection) Rules 1986 and MPCB, A-II standards in all the surface water samples.
12. Therefore, it can be concluded that surface water quality is affected by high pH. However, as compared to surface water quality the ground water quality in major part of the study area is affected by industrial and anthropogenic pollution.
13. The ground water of area is not suitable for drinking purpose as TH, NO_3, Fe, Pb and Mn concentrations are found above MPL prescribed by BIS, 2012.