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MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD



**GROUND WATER POLLUTION AROUND INDUSTRIAL
CLUSTERS IN MIDC AREA, CHANDRAPUR DISTRICT,
MAHARASHTRA
(AAP 2010-11)**

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नागपुर / NAGPUR

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MIDC AREA, CHANDRAPUR DISTRICT, MAHARASHTRA.
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**GROUND WATER POLLUTION IN THE INDUSTRIAL CLUSTERS IN
MIDC AREA, CHANDRAPUR DISTRICT, MAHARASHTRA.
(AAP 2010-11)**

1. Introduction:

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

The Central Pollution control Board (CPCB), in association with Indian Institute of Technology (IIT), New Delhi, has carried out an environmental assessment of Industrial clusters across the country based on Comprehensive Environmental Pollution Index (CEPI) with the aim of indentifying pollution in industrial clusters 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, Chandrapur is one of them.

The Sampling Area:

Chandrapur district is one of the eleven districts of Vidarbha Region of Maharashtra. It is bounded on south by Andhra Pradesh State, east by Garhchiroli district, on north by Gondia, Bhandara, Nagpur and Wardha districts and on the west by Yavatmal district. Wardha River forms the western boundary, whereas Wainganga River forms the eastern boundary of the district. The district lies between 19°30' and 20°45' north latitudes and 78°46' and 80°00' east longitudes. It falls in parts of the Survey of India Tooposheet No. 55H, 55L, 56E and 56I covering an area of 10920 sq.km.

The sampling area covers MIDC area of Chandrapur District. MIDC is located 7 Kms North West of the main Chandrapur city on Chandrapur-Nagpur Highway. The area covers about 20 sq. km. and lies between North latitude 19°58'36" and East longitude 79°14'09". The villages Wadgaon, Padmapur, Durgapur, Urjanagar Colony, CSTP Plant Pump House, Chargaon, Wichoda, Chota Nagpur, Khutala, Wandhari, Chinchala, Gangagir, Datala and

Tadali constitute the sampling area. The main industries located in the area are Pharmaceuticals, Pulp & Paper and Paper products, Distilleries and Metal, Aluminium, Metal Engineering, Tyre, Biotech, Pesticides etc.

2. Climate and Rainfall:

The Climate of the area is characterised by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. The temperature rises rapidly after February till May, which is the hottest month of the year. The mean daily maximum temperature during May is 42.8°C and the mean daily minimum temperature during December is 12.2°C. The normal annual rainfall of Chandrapur district is 1277.47 mm.

3. Geomorphology:

Chandrapur district is divided into two physiographic regions i.e., plane region in valleys of Wardha, Penganga and Wainganga Rivers and upland Hilly Region. The plane region is made up of widely spread and flat terrain occurring mostly along Wardha River. The upland hilly region lies between Wardha and Wainganga rivers. The entire area of the district falls in Godavari basin. Wardha, Wainganga and Penganga are the main rivers flowing through the district. These three rivers along with their tributaries rise in the upland within the district and drain the entire district.

4. Soil:

Different types of soils are observed in the district and each type supports a well defined cropping pattern of totally different type. The soils of Wardha and Wainganga valleys are most fertile. The different types of soils occurring in the district are locally called as Kali, Kamhar, Morand, Khardi, Wardhi, Retari, Bardi and Pandhari. Out of above Morand is the most common soil occurring in the district and is suitable for irrigation due to its loamy texture, whereas, on Wardhi soil, paddy growing areas are observed in parts of Brahmapuri, Chimur and Nagbhid talukas.

5. Ground Water Regime:

5.1 Hydrogeology:

The major water bearing formations in the district are Alluvium, Lower Gondwana Sandstones, Deccan Trap Basalts, Vindhyan Limestones and Archean Metamorphics. Amongst these, the Lower Gondwana Sandstones, particularly Kamthi Sandstone form the most potential aquifer.

5.1.1 Depth to Water Level – Pre monsoon (May 2011):

The depth to water levels in the district, during premonsoon, ranges between 1.70 (Chora) and 18.30 (Ajaypur) m bgl. Shallow water levels within 10 m bgl are seen in almost entire district except few isolated patches in south western parts of Warora and Bhadravati talukas and small parts of Brahmapuri, Gondpipri and Chandrapur talukas where water level ranges between 10-20 m bgl.

Very shallow water levels of less than 5 m bgl are also observed in major part of Chimur taluka and parts of Sindewahi and Bhadravati talukas. The deeper water levels are generally observed in soft rock areas.

5.1.2 Depth to Water Level – Post monsoon (November 2011):

The depth to water levels during postmonsoon ranges between 1.00 m bgl (Rajoli Tukkum) and 13.55 m bgl (Bhandak). Shallow water levels within 10 m bgl are observed in entire district with dominant range being 2-5 m bgl followed by 5-10 m bgl range. Very shallow water levels of less than 2 m bgl are observed in eastern part of the district comprising parts of Sindewahi, Mul and Brahmapuri talukas, whereas water levels of 2-5 m bgl are observed in northern, north western, north eastern and south eastern parts of the district. Water levels in the range of 5-10 m bgl are mainly observed in south eastern parts of the district.

6. Hydrochemistry:

Sampling:

Overall, 23 water samples were collected during field investigation. Eleven water samples were collected from shallow aquifer ie dug wells and eleven samples from deeper aquifer ie hand pumps and tube wells while one water sample was collected from surface water. The details about the locations and sources of the samples are given in Table- 1.

Table1: The Details of Locations, Sources of Water Samples and Results of Chemical Analysis

| S/N | Locations | Source | pH | EC | TDS | TA | TH | NO ₃ | F | RSC |
|-----|-----------------------|--------|-----|------|------|-----|------|-----------------|------|-------|
| 1 | Padmapur | DW | 8.8 | 530 | 345 | 100 | 300 | 87 | BDL | -4 |
| 2 | Padmapur | HP | 9.0 | 230 | 150 | 70 | 220 | 29 | BDL | -3 |
| 3 | Durganagar | DW | 8.4 | 630 | 410 | 190 | 230 | 0.4 | BDL | -0.8 |
| 4 | Urja Nagar Collony | HP | 8.4 | 590 | 384 | 300 | 430 | BDL | BDL | -2.6 |
| 5 | CSTP Plant Pump House | TW | 8.1 | 1560 | 1014 | 470 | 560 | BDL | 0.39 | -1.8 |
| 6 | Chargaon | DW | 8.5 | 900 | 585 | 180 | 380 | 117 | 0.29 | -4 |
| 7 | Chargaon | HP | 8.5 | 580 | 377 | 210 | 250 | 64 | 1.2 | -0.8 |
| 8 | Wichoda | DW | 7.7 | 3450 | 2243 | 280 | 930 | 286 | 0.32 | -13 |
| 9 | Wichoda | HP | 7.8 | 3960 | 2574 | 160 | 1150 | 370 | BDL | -19.8 |
| 10 | Chhota Nagpur | DW | 8.0 | 2510 | 1632 | 130 | 910 | 272 | 0.16 | -15.6 |
| 11 | Chhota Nagpur | HP | 7.9 | 2950 | 1918 | 160 | 680 | 295 | BDL | -10.4 |
| 12 | Wadgaon | HP | 7.9 | 2450 | 1593 | 690 | 290 | 29 | 0.83 | 8 |
| 13 | Khutala | DW | 8.1 | 2120 | 1378 | 310 | 430 | 11.2 | 1.33 | -2.4 |

| | | | | | | | | | | |
|----|-----------|----|-----|------|------|-----|-----|-----|------|------|
| 14 | Vandhari | DW | 8.3 | 1700 | 1105 | 490 | 510 | 266 | 0.1 | -0.4 |
| 15 | Chinchala | DW | 8.0 | 2870 | 1866 | 320 | 680 | 233 | 1.2 | -7.2 |
| 16 | Chinchala | HP | 8.2 | 2320 | 1508 | 340 | 740 | 290 | 1.32 | -8 |
| 17 | Gagangir | DW | 8.3 | 1850 | 1203 | 480 | 400 | 22 | 1.42 | 1.6 |
| 18 | Gagangir | HP | 8.3 | 1520 | 988 | 310 | 310 | BDL | 1.14 | 0 |
| 19 | Datala | DW | 7.8 | 4510 | 2932 | 390 | 660 | 184 | 0.6 | -5.4 |
| 20 | Datala | TW | 8.4 | 1120 | 728 | 250 | 560 | 11 | BDL | -6.2 |
| 21 | Tadali | TW | 8.3 | 960 | 624 | 580 | 230 | BDL | 1.14 | 7 |
| 22 | Tadali | DW | 8.5 | 610 | 397 | 360 | 190 | BDL | 0.78 | 3.4 |
| 23 | Gagangir | SW | 8.1 | 1990 | 1294 | 210 | 390 | 142 | BDL | -3.6 |

Analysis

Inorganic constituents like Total Alkalinity (TA), Cl, NO₃, F, and Total Hardness (TH), are determined along with physical parameters like pH and Electrical conductivity (EC) to study the surface and ground water quality of the study area (Table-I). Analysis of trace metals like Pb, Mn, Cu, Zn and Fe were 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 samples in the area under investigation are presented in Table 1 and explained below.

6.1 pH:

The pH of ground water generally lies in the range of 6-8 which may be affected due to contamination of groundwater by acidic or alkaline effluents.

In the study area the pH of ground water lies in the range of 7.7 to 9.0. All the samples have shown alkaline range.

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

The determination of EC and TDS were carried out to know the extent of mineralisation of ground water in the study area. In basalts, the average EC and TDS values are generally 1000 $\mu\text{S}/\text{cm}$ at 25⁰C and 570 mg/l respectively.

The EC values of ground water samples collected from shallow aquifer i.e. dug well are in the range of 530 to 4510 $\mu\text{S}/\text{cm}$ at 25⁰C and from deeper aquifer i.e. bore wells are in the range of 230 to 3960 $\mu\text{S}/\text{cm}$ at 25⁰C. The EC values of sample collected from surface water is 1990 $\mu\text{S}/\text{cm}$ at 25⁰C.

6.3 Nitrate:

In the area under investigation, the nitrate concentration of ground water lies in the range of BDL to 370 mg/l. The higher values are recorded in the well water of town area where sewage waste and garbage are dumped.

The nitrate content of ground water samples collected from shallow aquifer i.e. dug well are in the range of BDL to 286 mg/l and from deeper aquifer i.e. bore wells are in the range of BDL to 370 mg/l. The nitrate content of sample collected from surface water is 142 mg/l.

6.4 Total Alkalinity:

In the area under investigation, Total Alkalinity in ground water lies in the range of 70 to 690 mg/l.

6.5 Fluoride:

Fluoride content in ground water lies in the range of BDL to 1.42 which is within the maximum permissible limit (1.5 mg/l) of ISI for drinking water.

The Fluoride content of ground water samples collected from shallow aquifer i.e. dug well are in the range of BDL to 1.42 mg/l and from deeper aquifer i.e. bore wells are in the range of BDL to 1.32 mg/l. The Fluoride content of sample collected from surface water is below detectable limit.

6.6 Total Hardness (TH):

Total Hardness in ground water lies in the range of 190 to 1150 mg/l. The concentrations of TH in 7 samples are above desirable limit and in 6 samples above maximum permissible limit.

The Total Hardness of ground water samples collected from shallow aquifer i.e dug well are in the range of BDL to 286 mg/l and from deeper aquifer i.e bore wells are in the range of 220 to 1150 mg/l. The Total Hardness of sample collected from surface water is 390 mg/l.

6.7 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 2.

Overall, the ground water quality in the monitored wells is good for irrigation purpose and there is a less possibility of developing sodium hazard.

Table 2- : Classification of Ground 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 | % |
| 23 | 19 | 83% | 1 | 4% | 3 | 13% |

It is observed from Table 2 that based on RSC values, 13% samples, wadgaon and two locations at Tadali, are unsuitable for irrigation purpose and 4% samples are classified as doubtful. RSC values of the 83% samples in the study area are classified as "Good" for irrigation purpose.

6.8 Trace Elements:

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 $\text{pH} < 5$.

In the area under investigation, 22 water samples were analyzed for trace elements like Cu, Mn, Pb, Cr, Zn and Fe. The analysis results are given in table 3. The results reveal that ground water contamination may occur due to the presence of lead.

Table 3: The Results of the Analysis of Surface and Ground Water Samples for Trace Elements

| Locations | Type of well | Cu | Mn | Fe | Pb | Zn |
|--------------------|--------------|-------|-------|-------|-------|-------|
| Padmapur | DW | BDL | BDL | 0.03 | BDL | 0.004 |
| Padmapur | HP | BDL | 0.195 | 3.258 | BDL | 0.308 |
| Durganagar | DW | BDL | 0.309 | 0.429 | 0.038 | 0.011 |
| Urja Nagar Collony | HP | BDL | 0.383 | 8.33 | BDL | 0.163 |
| Chargaon | DW | BDL | BDL | 0.04 | 0.054 | 0.014 |
| Chargaon | HP | BDL | BDL | 0.428 | 0.073 | 0.039 |
| Wichoda | DW | BDL | BDL | 0.082 | 0.099 | 0.03 |
| Wichoda | HP | 0.03 | 0.402 | 0.524 | 0.11 | 0.1 |
| Chhota Nagpur | DW | BDL | BDL | 0.192 | BDL | 0.011 |
| Chhota Nagpur | HP | 0.007 | 0.216 | 4.878 | BDL | 0.128 |

| | | | | | | |
|-----------|----|-------|-------|-------|-------|-------|
| Wadgaon | HP | BDL | BDL | 0.718 | 0.045 | 0.157 |
| Khutala | DW | BDL | 0.009 | 0.053 | BDL | 0.004 |
| Vandhari | DW | BDL | BDL | 0.08 | BDL | BDL |
| Chinchala | DW | BDL | 0.031 | 0.127 | 0.045 | BDL |
| Chinchala | HP | 0.008 | BDL | 0.449 | 0.055 | 0.112 |
| Gagangir | DW | BDL | 0.04 | 0.02 | BDL | 0.016 |
| Gagangir | HP | 0.033 | 0.453 | 6.324 | 0.11 | 1.153 |
| Datala | DW | 0.013 | BDL | 0.071 | 0.106 | 0.053 |
| Datala | TW | BDL | BDL | 0.348 | BDL | 0.013 |
| Tadali | TW | BDL | BDL | 0.031 | 0.076 | 0.023 |
| Tadali | DW | BDL | BDL | BDL | 0.095 | BDL |
| Gagangir | SW | BDL | 0.137 | 0.151 | 0.08 | BDL |

6.8.1 Manganese (Mn):

The major forms of Manganese in nature are oxides, silicates and carbonates. It is widely distributed in soil. It is 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 max. permissible limit is 0.3 mg/L as per BIS standard for drinking water.

The concentration of Manganese found in the ground water of study area are in the range of BDL to 0.453 mg/l in deeper level while at shallow depth it ranges from BDL to 0.309 mg/L. The high concentration of Mn was recorded in the wells located at Durganagar,

wichoda, Urjanagar colony and Gagangir. The concentration of Manganese found in the surface water of study area is 0.137 mg/l.

6.8.2 Iron (Fe):

Iron in ground water generally exists as Fe(II) but may be 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. In spite of heavy discharge of Iron in the atmosphere and on land, solubility controls restrict migration of the Iron to the saturated zone. The iron content in ground water is in the range of BDL to 0.429 mg/L in dug well samples while in deeper level i.e in Hand Pump and Tube Well samples, it ranges from 0.031 to 8.33 mg/L. In surface water the content of iron is 0.151 mg/L. The drinking water standard for Iron is 0.3 (Desirable limit) to 1.0 mg/L (Max. permissible limit). The concentration of more than permissible limits are recorded in the hand pump water samples from Padmapur (3.258mg/L), Chota Nagpur (6.324 mg/L), Gangangir (6.324 mg/L) and Urja Nagar Colony (8.33 mg/l).

6.8.3 Lead (Pb):

The natural lead content of lake and river water worldwide is in the range of 0.001 to 0.01. Permissible limit for Pb concentration is 0.05mg/L with no relaxation. 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 area indicate that the lead content of dug wells ranges from BDL to 0.106 mg/L while in Hand Pumps and Tube wells it ranges from BDL to 0.11 mg/L. In surface water, the Concentration of Pb is 0.08 mg/L. High concentration of Lead in this area can directly be linked with the industrial activities in the area.

6.8.4 Copper (Cu):

The copper found in ground water of MIDC study area varies from BDL to 0.033 mg/L. This is also essential micronutrient and very likely to come through the spent wash of

distillery. As per drinking water Standard, desirable and permissible limits for concentration of Cu are 0.05 and 1.5 mg/l respectively. The maximum concentration of 0.033 mg/L is recorded in the Hand Pump located at Gagangir area and all the samples are within desirable limits.

6.8.5 Zinc (Zn):

The zinc content in surface and ground water in MIDC study area varies from BDL to 1.153 mg/L. All the ground water samples contain zinc below the desirable limit of BIS (5 mg/L) for the drinking water.

6.9 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 industrial effluents wastes discharged in unlimited quantity in small channels, low lying areas and pits come in contact with surface and ground water and cause 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 is retained 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 spread out laterally, floating on the top of aquifer and move 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.

6.10 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 and maximum permissible limits as given by BIS for drinking water in IS-10500-91, Revised 2003 standards for the parameters viz., TDS, TH, Ca, Mg, Cl, SO₄ and NO₃ is given in Table 4.

Table 4: Classification of Ground Water Samples based on BIS Drinking Water Standards (IS-10500-91, Revised 2003)

| 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-11 HP-8 TW-3 SW-1 | DW- Nil HP- Nil TW- Nil SW- Nil | DW-10 HP-7 TW-3 SW-1 | DW-1 HP-1 TW- Nil SW- Nil |
| | Total | | 23 | Nil | 21 (91%) | 2 (9%) |
| TDS (mg/L) | 500 | 2000 | DW-11 HP-8 TW-3 SW-1 | DW-3 HP-3 TW- Nil SW- Nil | DW-6 HP-4 TW-3 SW-1 | DW-2 HP-1 TW- Nil SW- Nil |
| | Total | | 23 | 6 (27%) | 14 (60%) | 3 (13%) |
| TH (mg/L) | 300 | 600 | DW-11 HP-8 TW-3 SW-1 | DW-2 HP-3 TW-1 SW-0 | DW-5 HP-2 TW-2 SW-1 | DW-4 HP-3 TW-0 SW-0 |
| | Total | | 23 | 6 (27%) | 10 (43%) | 7 (30%) |
| TA (mg/L) | 200 | 600 | DW-11 HP-8 TW-3 SW-1 | DW-4 HP-3 TW-0 SW-0 | DW-7 HP-4 TW-3 SW-1 | DW-0 HP-1 TW-0 SW-0 |
| | Total | | 23 | 7 (30%) | 15 (65%) | 1 (5 %) |
| NO ₃ (mg/L) | 45 | No relaxation | DW-11 HP-8 TW-3 SW-1 | DW-4 HP-4 TW-3 SW-0 | DW-7 HP-4 TW-0 SW-0 | DW- Nil HP- Nil TW- Nil SW- 1 |
| | Total | | 23 | 11 (48%) | 11 (48%) | 1 (4%) |
| F (mg/L) | 1.0 | 1.5 | DW-11 HP-8 TW-3 SW-1 | DW-8 HP-5 TW-2 SW-1 | DW-3 HP-3 TW-1 SW-0 | DW- Nil HP- Nil TW- Nil SW- Nil |
| | | | 23 | 16 (70%) | 7 (30%) | Nil |

| | | | | | | |
|----------|------|------|-------------------------------|-------------------------------|------------------------------|------------------------------|
| Fe(mg/L) | 0.3 | 1.0 | DW-11 HP-8 TW-2 SW-1 | DW-10 HP-0 TW-0 SW-1 | DW-1 HP-4 TW-2 SW-0 | DW-0 HP-4 TW-0 SW-0 |
| | | | 22 | 11 (50%) | 7 (30%) | 4 (20%) |
| Pb(mg/L) | 0.05 | 0.05 | DW-11 HP-8 TW-3 SW-1 | DW-7 HP-4 TW-1 SW-0 | DW-0 HP-0 TW-1 SW-0 | DW-4 HP-4 TW-0 SW-1 |
| | | | 22 | 12 (55%) | 1 (4%) | 9 (41%) |
| Zn(mg/L) | 5 | 15 | DW-11 HP-8 TW-2 SW-1 | DW-11 HP-8 TW-2 SW-1 | DW-0 HP-0 TW-0 SW-0 | DW-0 HP-0 TW-0 SW-0 |
| | | | 22 | 22 (100%) | Nil | Nil |
| Cu(mg/L) | 0.05 | 1.5 | DW-11 HP-8 TW-2 SW-1 | DW-11 HP-8 TW-2 SW-1 | DW-0 HP-0 TW-0 SW-0 | DW-0 HP-0 TW-0 SW-0 |
| | | | 23 | 22 (100%) | Nil | Nil |
| Mn(mg/L) | 0.1 | 0.3 | DW-11 HP-8 TW-2 SW-1 | DW-10 HP-3 TW-2 SW-1 | DW-0 HP-2 TW-0 SW-0 | DW-1 HP-3 TW-0 SW-0 |
| | | | 22 | 16 (73%) | 2 (9%) | 4 (18%) |

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

The perusal of Table 4 reveals that concentration of TH, Fe, Pb is above desirable limit but below maximum permissible limit in most of the cases. In trace metals, the concentration of Fe in 20% samples, Pb in 41% samples, Mn in 18% samples are beyond the maximum permissible limit while the Zinc and Copper concentrations are within permissible limit.

Therefore, it can be concluded that 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.

7. Findings:

Overall 23 water samples were collected during field investigation. Eleven water samples were collected from shallow aquifer ie dug wells, eleven samples from deeper

aquifer ie hand pumps and Tube wells while one water sample was collected from surface water. The water samples were analysed to determine quality of surface and ground water. Nearly 200 industries are distributed within industrial area limits.

On the basis of close examination of analytical results, following findings have been drawn as discussed below:

1. The PH of ground water lies in the range of 7.7 to 9.0, all the sample are showing alkaline range.
2. The EC values of ground water are in the range of 230 to 4510 $\mu\text{S}/\text{cm}$ at 25⁰C. The most of the samples in the area are having EC values more than 2500 $\mu\text{S}/\text{cm}$ indicating that there is substantial deviation from background values. The EC values of ground water samples collected from shallow aquifer i.e. dug well are in the range of 530 to 4510 $\mu\text{S}/\text{cm}$ at 25⁰C and from deeper aquifer i.e. bore wells are in the range of 230 to 3960 $\mu\text{S}/\text{cm}$ at 25⁰C. The EC values of sample collected from surface water is 1990 $\mu\text{S}/\text{cm}$ at 25⁰C indicating that pollution intensity is moderate in the area.
3. The nitrate content of ground water samples collected from shallow aquifer i.e. dug well are in the range of BDL to 286 mg/l and from deeper aquifer i.e. bore wells are in the range of BDL to 370 mg/l. The nitrate content of sample collected from surface water is 142 mg/l.
4. The Fluoride content of ground water samples collected from shallow aquifer i.e. dug well are in the range of BDL to 1.42 mg/l and from deeper aquifer i.e. bore wells are in the range of BDL to 1.32 mg/l. The Fluoride content of sample collected from surface water is below detectable limit which is within the maximum permissible limit (1.5 mg/l) of BIS for drinking water.
5. The Total Hardness of ground water samples collected from shallow aquifer i.e. dug well are in the range of BDL to 286 mg/l and from deeper aquifer i.e. bore wells are in the range of 220 to 1150 mg/l. The Total Hardness of sample collected from surface water is 390 mg/l.
6. The concentration of Manganese found in the ground water of study area are in the range of BDL to 0.453 mg/l in deeper level while at shallow depth it ranges from BDL

to 0.309 mg/L. The highest concentration was reported in the wells located at Durganagar, wichoda, Urjanagar colony and Gagangir. The concentration of Manganese found in the surface water of study area is 0.137 mg/l.

7. The iron concentration in ground water is in the range of BDL to 0.429 mg/L in dug well samples while in deeper level i.e in Hand Pump and tube well samples it ranges from 0.031 to 8.33 mg/L. In surface water the content of iron is 0.151 mg/L. The drinking water standard for Iron is 0.3 (Desirable limit) to 1.0 mg/L (Max. permissible limit). The highest concentration of 8.33 mg/L was reported in the sample of Urja Nagar Colony.
8. The lead concentration in dug wells samples ranges from BDL to 0.106 mg/L while in Hand Pumps and Tube wells samples it ranges from BDL to 0.11 mg/L. In surface water the concentration of Pb is 0.08 mg/L which is more than Max permissible limit of 0.05mg/L. High concentration of Lead in this area can be directly linked with the industrial activities in the area. The maximum concentration of 0.11 mg/L is recorded in the Hand Pump sample located at Gagangir area.
9. The concentrations of Cu & Zn are found below permissible limits.