

Final Report

Investigations on Water Sources in 14 Villages of Tamnar Block of Raigarh District, Chhattisgarh

Sponsor



**Maharashtra State Power Generation Company Limited
(MSPGCL), Mumbai, Maharashtra**



ISO 9001:2008

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DISCLAIMER

CSIR-NEERI undertook investigations of the water sources on request of **Maharashtra State Power Generation Company Limited (MSPGCL)**, Government of Maharashtra. This study is to assist the Department for taking appropriate decision on the water quality of both ground water and surface water sources in the areas surrounding the mining area and its effect on human health.

This report should not be utilized for any commercial activities except for reference purposes.

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I. Background and Introduction

Maharashtra State Power Generation Company Limited (MSPGCL) is a State owned Public Sector Unit of Government of Maharashtra engaged in power generation having its Head Office situated in Bandra (East), Mumbai. MSPGCL has proposed developing Gare Palma Sector II Coal Mine located in Mand Raigarh Coalfield, Chhattisgarh for its captive use. The proposed site falls in Mand Raigarh Coalfield belt and the mine area / project area / applied ML area is 2583.48 Ha. The coal mine covers total of 14 villages viz. Dolesara, Pata, Mudagaon, Saraitola, Kunjemura, Chitwahi, Bhalumura, Rodopali, Dholnara, Gare, Tehlirampur, JhinkaBahal, Libra and Sarasmal in Raigarh district. Developmental activity like industry or mining may cause temporary damage to land, forest and induce changes in the quality of air, water, flora and fauna of the area. Mining and its associated activities not only utilize substantial quantity of water but also affect the hydrological regime which in turn may affect the water quality. There is a river, seasonal water body and few water courses within the mine site and there are few water courses within the site that drain rainwater outside the mine site. The major hydrological impact of a large and deep opencast or underground mine if any, might be mainly on the ground water regime of the region. It is given to understand that the Environmental Impact Assessment of the “Proposed Gare Palma Sector II Coal Mine” in the district was carried out by Ramkey Enviro Engineers Limited Hyderabad and the draft report for public hearing was submitted to MSPGCL, Mumbai in February 2017.

With the above background, it is discerned through the letter dated April 4, 2018 from The Joint Secretary, National Commission of Scheduled Tribes (NCST), Government of India addressed to The Secretary, MOEF, New Delhi; The Chief Secretary, Government of Chhattisgarh, Raipur; Member Secretary Chhattisgarh Environment Conservation Board, Raipur; and Collector and DM, Raigarh, Chhattisgarh that in a meeting held on April 2, 2018 at the District Collector’s office, Raigarh where The

Chief Engineer, MSPGCL made presentation on the aforementioned project and its impact on Scheduled Tribe habitans residing in the project area; the Scheduled Tribe representatives present in the meeting narrated likely social and environmental adverse impacts of the project in 12 villages affected in Tamnar Block. The Chief Medical Officer, Raigarh further highlighted the increase in number of persons affected due to skin diseases as also tuberculosis and asthma in the district and consequent health hazards being faced by habitans in the affected villages. It was mentioned that in the Tamnar block, (i.e. the study area) the prevalent cases of skin diseases were about 2700 whereas asthma / bronchitis were 10% higher than the normal.

In view of the above, the NCST expressed to have report/ documents on the said matter through MOEF, New Delhi. It is also mentioned in the aforementioned letter that CSIR-NEERI be requested to undertake the investigations on drinking water sources in the affected villages of Tamnar block of Raigarh district and submit the report.

With reference to the letter dated June 28, 2018, from Deputy Secretary, Industry, Power and Labour Department, Government of Maharashtra, on subject” NCST Objections to Methodology for Conducting Public Hearing in Gare Palma Sector II Coal Mine Project in 12 Villages of Raigarh District in Chhattisgarh over an area of 2583.48 hectares by M/s Maharashtra State Power Generation Company Ltd. – Deferment of Public Hearing Scheduled on 17.04 2018” (received by CSIR-NEERI) – enclosing a copy of the letter from Director, Office of the commissioner, ST& SC Development, Raipur, Chhattisgarh; and subsequent meeting held with the then Director (Mining) of Mahagenco, Mumbai at CSIR-NEERI, Nagpur; considering the significance and urgency of the matter; CSIR-NEERI team would undertake visit to the affected villages of Tamnar block for collection of water samples. The water quality report shall be submitted to MSPGCL, Mumbai; District Collector Raigarh; NCST, New Delhi; MOEF, New Delhi and other important stakeholders.

II. Objectives

Collection and evaluation of drinking / domestic water sources in 14 villages in Tamnar Block of Raigarh District, Chhattisgarh and suggest methodology for remediation of contaminated sources, if any.

III. Work Plan

- Field visits to 14 villages of Tamnar Block
- Collection of site specific information in consultation with Public Health Engineering Department (PHED), Government of Chhattisgarh
- Sampling of drinking / domestic sources with the assistance of PHED officials, Raigarh immediately after receiving the work order followed by second sampling during winter to have appropriate water quality scenario in the block
- Characterization and quantitative evaluation of ground and lake water samples with respect to physico-chemical and bacteriological parameters including health related geogenic contaminants like arsenic and fluoride and nitrate besides metals
- Explore establishing correlation between prevalent water borne diseases collected through secondary data / socio-economic survey and water quality
- Suggest methodology for remediation of contaminated sources, if any

IV. Scope of work

- Collection of the details such as location, habitats, and water sample collection from the water sources of 14 villages of Tamnar district
- Socio-Economic survey of all the villages and the conditions of the habitants in these villages
- Preservation, transportation and laboratory analysis of the water samples for identification of the contaminants
- Preparation of the report based on the analysis and socio-economic survey

V. Field Visit, Sampling, Analysis and Observations

- Field visit to the 14 villages of Tamnar district was carried out during September 4-7, 2018 by team CSIR-NEERI for collection of water samples besides site specific information. Water sources used by the villagers for drinking and other domestic purposes were identified and the samples were collected from the respective water sources under the guidance of officials of PHED, Raigarh. Bacteriological laboratory was temporarily setup at the Hotel in Raigarh where the samples were analysed for coliforms the same day subsequent to the collection of samples.

VI. Quality of Water Sources in 14 Villages under Study Area

The sampling locations are given in Table 1. Physico-chemical and bacteriological water quality of 14 villages in Tamnar Block is depicted in Tables 2 through 15. Water quality results with respect to metals are given in Table 16. Village-wise details of water sources and water quality results are discussed below.

1. Dolesara Village

The sources of water in Dolesara village are tube wells attached to hand pumps (will be referred as hand pump), a dug well and a pond. The hand pumps serve as the main source of drinking water to the villagers. The dug well is used for washing clothes and the pond water is used mostly for bathing and washing. Sampling was carried out at six locations including the pond.

The physico-chemical and the microbial water quality results are depicted in **Table 2**. The physico-chemical parameters for hand pumps and the dug well were found to be within the permissible limits of water quality standards prescribed by the BIS. (IS 10500: 2012) except for turbidity in samples DOL-1, DOL-3, DOL-4, DOL-5 and

DOL-6 ranging from 6 NTU to as high as 75 NTU and acidic pH of 5.9 observed in the pond water sample. The pond DOL-6 though not used for drinking was found to be highly contaminated with total and faecal coliforms. Also faecal contamination was observed in samples DOL-2, DOL-3, and DOL-5. High concentrations of iron were observed to be present in samples DOL-1 and DOL-5; highest being in DOL-5 having Fe concentration of 3.0 ppm (Table 16). Manganese and lead were found to be above the permissible limit in samples DOL-2 and DOL-5 respectively as is evident from Table 16. **Alarming levels of arsenic ranging from 0.2 to 0.8 ppm were observed in all the water sources in Dolesara village.** However, its presence in alarming concentrations, if any, or its absence may be confirmed only after periodic sampling for couple of years. Socio economic survey revealed that drinking water was available perennially and the hand pump / bore well surroundings were observed to be well guarded and cleanliness was observed to be maintained in the vicinity of the water sources. About 80% of the habitants of Dolesara were known to be engaged in farming. Fever was the only health concern reported by the habitants of the village.

2. Pata Village

Pata village has a pond, a dug well and hand pumps as water sources. The hand pumps are the main sources of drinking water. It was informed by the villagers that the dug well was used occasionally for domestic purposes and water is available perennially in the hand pumps. The pond water is used only for domestic purposes like washing and bathing.

Water quality results are given in **Table 3**. The water from sources PATA-1, PATA-2 and PATA-3 were observed to be slightly acidic. Turbidity of 12 NTU was observed to be above the permissible limit of 5 NTU prescribed by the BIS (IS 10500:2012) in PATA-4 hand pump sample. Nitrate was found to be present above the acceptable limit of 45 mg/L in sample PATA-1. Metal analysis results are depicted in Table 16. **Arsenic was observed to be present above the permissible limits of 0.01 ppm as per the BIS**

Standard in all the four samples analysed from the village sources. However, a couple of times more sampling and analysis can only confirm its presence / absence at alarming concentrations, if any. Faecal contamination was observed in all the samples except in PATA-2. Scaling of teeth with yellow tinge was observed in some of the adults. This may be attributed to high levels (above the acceptable limits and within the permissible limits) of fluoride in samples PATA-3 and PATA-4 as is evident from analysis results.

3. Mudagaon Village

Sampling in Mudagaon village was done at four locations from hand pumps which served as the main sources of drinking for the villagers. Water quality results are given in **Table 4**. Sample MUD-2 was observed to be slightly acidic (pH-6.3) while samples MUD-1, MUD-2 and MUD-3 were found to have high turbidity of 6 NTU, 60 NTU and 25 NTU respectively. High concentration of fluoride i.e. 2.3 mg/L was observed in MUD-4. Scaling and yellow to red tinge in teeth were also observed in some of the habitants.



Figure 1: Socio Economic Survey at Mudgaon Village

Iron was observed to be 8.0 ppm which is well above the acceptable limit of 1.0 ppm as prescribed by the BIS as is evident from the Table 16. Hence, the turbidity of as high as

60 NTU may be attributed to the presence and precipitation of iron salts in the sample. Rest of the metals are within the standards of BIS 10500:2012 **except for high concentrations of arsenic ranging from 0.03 to 0.04 ppm in all the four samples.** Presence of Faecal coliforms was observed in all samples except in MUD-3. Socio economic survey was conducted along the sampling in the village as seen from **Fig 1.** The woman in the figure had scaling and redness in her teeth and was quite aware of the adverse health effects of contaminated water.

4. Saraitola Village

Water samples were collected from four locations in Sariatola village. Hand pumps are the main sources of drinking water in this village. There was also a pond situated in the outskirts of the village, however, not used for either drinking or domestic purposes. In this village the water was pumped and stored in storage tank (through the bore well) from which it is supplied through pipes. Physico-chemical and microbial water quality of the ground water sources is depicted in **Table 5.** All the four water sources exhibit acidic pH, 5.1 to 6.1, as also high turbidity ranging from 7-380 NTU highest being in the sample SARA-2. Similarly, high concentrations of iron (Table 16), were observed, in all the four samples ranging from 7-32 ppm; the highest being in SARA-2. The high values of turbidity may certainly be attributed to the corresponding high iron content and precipitation of iron salts in all the samples. Red coloured stains were observed on the hand pump platforms indicating high levels of iron. **Figure 2** shows the sample collection from a bore well in Saraitola village. **Arsenic was found in alarming concentrations in all the four samples.** Besides iron; manganese and nickel were found be present beyond the permissible limits in samples SARA-2, SARA-3, SARA-4 and SARA-1, SARA-3 and SARA-4 respectively. Fluoride concentration were found to be high in samples SARA-2 (4.7 mg/L), SARA-3 (2.6 mg/L) and SARA-4 (2.6 mg/L) beyond the permissible limit of 1.5 mg/L for drinking water as prescribed by the BIS. Yellow scaling of teeth and turbid water were the issues reported by the villagers.



Figure 2: Sample Collection from Bore Well in Saraitola Village

5. Kunjemura and Kunjemura Mohalla

Kunjemura village had a larger population comparatively and hence it was divided into Kunjemura and Kunjemura mohalla. A total of nine samples were collected from this village. Apart from hand pumps, bore well and dug well also served as drinking water sources. The physico-chemical and bacteriological water quality is depicted in the **Tables 6** and **Table 6a** for Kunjemura Mohalla and Kunjemura Village respectively while metal analysis results are given in Table 16. Red staining of the surface of platform around hand pumps as also near the some of the water sources was observed along with scaling in the storage tanks. This could be attributed to the presence of excess iron and manganese in ground water as is evident from Table 16. Turbidity as high as 51 NTU (Table 6) with corresponding iron concentration of 30 ppm (Table 16) was observed in sample KUN-15 collected from a hand pump near Nityanand Nishad's House in Kunjemura Mohalla. High turbidity was also observed in samples KUN-1 (90 NTU), KUN-2 (22 NTU) and KUN-3 (8 NTU) collected from the village Kunjemura (Table 6a). Excessive nitrate of 120 mg/L was found in the Dug Well (KUN-4).

Arsenic of the order of 0.02 ppm was found in sample KUN-3. Faecal Coliforms were observed in samples KUN-11 and KUN-12 (Table 6) and KUN-2 and KUN-4 (Table 6a). **Figure 3** shows sampling activity and red staining at the hand pump platform in village Kunjemura depicting high concentration of iron in the water source. Red pigmentation and scaling of teeth were the health issues reported by the villagers.



Figure 3: Red Stains around Hand Pump in Kunjemura Village

6. Chitwahi Village

A total of six samples were collected from Chitwahi village from bore well, hand pump and lake. Bore wells and hand pumps served as the major drinking water sources in the village. It was informed that the hand pumps mostly dry up in summer season as a result of the decrease in the ground water level. Hence, deep bore wells serve as drinking water source during summer seasons. The physico-chemical and bacteriological water quality is given in the **Table 7** while metal analysis results are given in Table 16. All the physico-chemical parameters are below the acceptable limits of IS 10500: 2012 except for high turbidity in CHI-5 (20 NTU) and high concentration

of nitrate (50 mg/L) in CHI-2. Faecal contamination was found in four of the six water sources ranging from 5 to 600 CFU/100 ml; highest being in the sample No CHI-5. This could be due to the unhygienic conditions near the water source (**Figure 4**). No major health complications besides red pigmentation and scaling of teeth were reported by the villagers.



Figure 4: Dug Well and Storage Tank in Chitwahi Village

7. Bhalumuda Village

A Solar power pump was seen installed in Bhalumuda village apart from bore wells which are the main sources of drinking water in the village. The physico-chemical and bacteriological water quality is given in the **Table 8** while metal analysis results are depicted in Table 16. All the physico-chemical parameters are within the permissible limits of IS 10500:2012, however, sample BHA-1 exhibits acidic nature with pH as low as 5.4. Faecal contamination was found to be present in all the four water sources ranging from 25 to 900 CFU/100 ml; highest being in the sample BHA-4. This could be due to the unhygienic conditions near the water source. Activities like washing and bathing were observed near the water source at the time of sampling which may have

lead to microbial contamination. No major health issues were reported besides fever and cough.

8. Rodopali Village

Bore wells are the perennial sources of drinking water in Rodopali village. Samples were collected from six bore wells. Physico-chemical and bacteriological water quality is depicted in **Table 9** while metal analysis results are given in Table 16. All the six bore wells were observed to have a good water quality; physico-chemical parameters being within the permissible limits of BIS. High concentration of manganese (0.6ppm), nickel (0.11ppm) and lead (0.01ppm) were found to be present in samples ROD-3 while 0.06 ppm of nickel was observed to be present in ROD-2 as is evident from Table 16. The surroundings of the water sources were observed to be neatly maintained. As a result no microbial contamination was detected in four of the sources analysed; however, faecal contamination was found to be present in sample ROD-4. No health issues were observed / reported in this village; however, minor scaling of teeth was observed in few cases.

9. Dholnara Village

Water samples were collected from six bore wells and a hand pump in the village. Physico-chemical and bacteriological water quality is depicted in **Table 10** while metal analysis results are given in Table 16. The samples DHO-6 and DHO-7 showed pH 5.8 which is below the acceptable limit as prescribed by the BIS; depicting acidic nature of water. Nitrate concentration of 121 mg/L above the permissible limit of 45 mg/L was observed in sample DHO-3. **Alarming levels of arsenic were observed to be present in all the samples ranging from 0.1 to 0.7 ppm.** However, its presence in alarming concentrations, if any, or its absence, may be confirmed only after periodic sampling for couple of years. Unhygienic conditions were observed near the hand pump (DHO-6). As a result, total and faecal coliforms were found to be high in the hand

pump sample. In spite of the high microbial contamination recorded, no major health issues were reported in this village.

10. Gare village

Bore wells and hand pumps were the main sources of drinking water in Gare. Eight water samples were collected for analysis from various water sources. Physico-chemical and bacteriological water quality is depicted in **Table 11** while metal analysis results are given in Table 16. All the water samples except GAR-4, GAR-5 and GAR-7 were found to be marginally or moderately acidic with pH ranging from 5.4 to 6.4, not conforming to the BIS standards of 6.5-8.5 for drinking water. Samples GAR-2 and GAR-8 showed turbidity of 26 NTU and 22 NTU respectively and observed to be beyond the BIS permissible range of 1-5 NTU. Fluoride was found to be above the acceptable limits yet within the permissible limits of 1.0-1.5 mg/L as laid down by the BIS. **Arsenic was found to be present with concentration beyond the acceptable limits of BIS in seven out of eight samples.** However, its presence in alarming concentrations, if any, or its absence; may be confirmed only after periodic sampling for couple of years. A variety of symptoms like blackening of teeth, yellow and red scale formation on teeth and reddening of the pipes and surfaces near the water sources were observed. Few cases including students were observed to have pale yellow scaling of teeth. This may be attributed to the high concentrations of fluoride, iron and/or manganese in the water sources. Few cases of Lymphatic Filariasis were also reported in this region. Faecal coliforms were observed in all the samples except GAR-2 and GAR-4. Unhygienic conditions like washing, bathing and urinating near the water source could be one of the reasons for the microbial contamination and health issues reported in this region. Photos could not be taken due to lack of co-operation of the villagers.

11. Tehlirampur

Tehlirampur is a sparsely populated village with less number of perennial bore wells which serve as drinking water sources. Hence, only two samples were collected from bore well storage tanks. Other available water sources were not used by the villagers. The water from bore wells was stored in the storage tanks and supplied to the users. Physico-chemical and bacteriological water quality is depicted in **Table 12** while metal analysis results are given in Table 16. A marginally acidic pH of 6.4 was observed in sample TEH-1. Nitrate concentration of 126 mg/L was found to be present in sample TEH-1 which is beyond the acceptable limit of 45 mg/L as prescribed by the BIS. Faecal coliforms were detected in TEH-1 and were found to be 58 CFU/100ml. Metals were found to be within the permissible limits of BIS **except for arsenic of 0.02 ppm in sample TEH-2**. No major health issues were observed in this village.

12. Jhinkabahal Village

Bore wells served as the main source of drinking water even though hand pumps were present in the village. The hand pumps were reported to dry up in summer season. Storage tanks were used regularly to supply water to the villagers. It was informed that frequent power cuts sometimes forced the villagers to drink water from the hand pumps. Further it was observed that the storage tanks were not cleaned regularly as algal growth could be seen on the storage tank walls (**Figure 5**). Jindal steels have installed a treatment unit for providing safe water to the villagers. Physico-chemical and bacteriological water quality is depicted in **Table 13** while metal analysis results are given in Table 16. Moderately low pH was observed in five of the six samples ranging between 5.3 and 6.2 and observed to be quite below the acceptable limit as per the BIS. Nitrate Concentration of 79 mg/L was observed in sample JHI-4 which was beyond the BIS acceptable limit of 45mg/L. Faecal coliforms ranging from 10-193 CFU/100ml were observed in all the samples except in JHI-5. High concentrations of

manganese 3 ppm and 26 ppm were found in samples JHI-3 and JHI-6 respectively. No major health issues were observed / reported in the village.



Figure 5: Algal Growth on the Walls of Storage Tank (Left); Water Treatment Unit installed by Jindal steels (Right) in Jhinkabahal village

13. Libra

Bore wells were the major source of drinking water in the village. Storage tanks were used to store bore well water for use of the villagers. Seven samples were collected for testing from bore wells and hand pumps. Physico-chemical and bacteriological water quality is depicted in **Table 14** while metal analysis results are given in Table 16. Water from four of seven sources was observed to be marginally to moderately acidic with pH ranging from 5.5 to 6.4 which is below the acceptable pH range of 6.5-8.5 prescribed by the BIS for drinking water. Turbidity of LIB-1 (8 NTU), LIB-2 (12NTU), LIB-4 (16 NTU) and LIB-5 (15 NTU) was found to exceed the BIS limit of 1-5 NTU for drinking water. Faecal coliforms were found to be present in samples LIB-3, LIB-4, LIB-5 and LIB-6. Iron was found to be in excess concentrations in samples LIB-1 (2 ppm) and LIB-5 (6 ppm). Water collected from the hand pump (sample LIB-2) as shown in **Figure 6** was turbid and orange/red in colour. Villagers complained of

vomiting, stomach ache and severe gastric problems on consumption of the hand pump water.



Figure 6: Unhygienic Condition in the Vicinity of Hand Pump (Left), Algal Growth and Scale Formation on the Walls of the Storage Tank in Libra village (Right)

14. Sarasmal (Kosampali)

Sarasmal (Kosampalli) village is situated around 200-300m away from the mine and comprise of two ponds. One pond was rain fed, located at the entrance of the village on roadside near mining area and used only for bathing and washing. Another pond was filled with water pumped from the mine area (**Figure 7**). **Figure 8** depicts a mine pit filled with rain water. Seven water samples were collected from bore wells, dug wells including water samples from the rain fed pond and the pond with water from the mine area. Physico-chemical and bacteriological water quality is depicted in **Table 15** while metal analysis results are given in Table 16. Except samples SARL-1 and SARL-7 all the other samples are marginally or moderately acidic with pH ranging from 5.5 to 6.4 which is below the pH range of 6.5-8.5 as prescribed by the BIS. High nitrate concentrations were found in samples SARA-2, SARA-3 and SARA-4 ranging from 82 to 133 mg/L. Turbidity was found to be 20 NTU in Sample SARL-6 beyond the BIS

limit with corresponding iron concentration of 1.0 ppm. Sample SARL-5 was observed to have manganese of 0.4 ppm while samples SARL-2 and SARL-4 were found to have 0.1 ppm of nickel above the acceptance limit as given by the BIS. Faecal coliforms were found in all the seven samples ranging from 5-300 CFU/100ml. People reported gastric problems and tooth decay and related problems. Reddish color deposits were also observed near the water sources such as hand pumps.



Figure 7: Pond receiving Water Pumped from the Mine in Sarasmal Village



Figure 8: Water Accumulation in the Mining Area near Sarasmal Village

VII. Observations by Team CSIR-NEERI

A. Water Quality Related

- One out of the total analysed water samples from villages Dolesara, Mudagaon, Bhalumuda, Dholenara and Tehlirampur were found to be marginally to moderately acidic. Most of the samples collected from villages Pata, Saraitola, Gare, Jhinkabahal, Libra and Sarasmal were observed to be marginally or moderately acidic.
- Turbidity was observed to be quite high in some of the water sources from villages Pata, Mudagaon, Saraitola, Kunjemura, Chitwahi, Dholnara, Gare, Libra and Sarasmal.
- Iron in excess of acceptable concentrations of BIS was observed in water sources in villages Dolesara, Mudagaon, Saraitola, Kunjemura, Rodopali, Dholnara, Gare, and Sarasmal.
- Samples from villages Dolesara, Pata, Mudagaon, Saraitola, Dholnara, Gare and few sources from Kunjemura and Tehlirampur were observed to have high levels of arsenic. However, on the day of sampling manifestations related to arsenic toxicity were not observed by team CSIR-NEERI.
- Fluoride was major issue in some of the water sources in villages Pata, Mudagaon, Saraitola and Gare.
- One to three out of the collected samples from villages Kunjemura, Chitwahi, Dholnara, Tehlirampur, Jhinkabahal and Sarasmal were found to have high levels of nitrate.
- Manganese, Nickel and lead were found in one or two water sources from some of the villages

B. Health Related

- Skeletal and dental fluorosis were observed in some cases in the villages of Saraitola and Gare and also reported by the health officials. The depth of the bore wells were reported to be more than 120 m in these villages. The fluoride concentration was found to be beyond the permissible limit of 1.5 mg/L as prescribed by the BIS in village Saraitola, while it was observed beyond the acceptable limit of 1.0 mg/L yet within the permissible limit of 1.5 mg/L of fluoride as given by BIS drinking water standards in village Gare.
- Socio economic survey of the villages and data from health centre of Tamnar district report Malaria, Diarrhoea, vomiting, stomach ache, skeletal fluorosis, dental fluorosis, gastric issues and skin pigmentation as some of the common diseases prevalent among the villagers throughout the year.
- Decaying and yellow to red coloured scaling of teeth was observed in the villagers of Libra, Gare, Mudagaon and Sarasmal.
- People also complained of vomiting, stomach ache and severe gastric problems in Libra and Sarasmal.

C. Hygiene and Management Related

- Unhygienic conditions near water sources, and improper sanitary habits were the common observations in all the villages.
- Red staining of the surface of platforms in the vicinity of hand pumps was observed in the villages of Libra, Gare, Mudagaon and Sarasmal.
- Most of the storage tanks in the villages were observed to be leaking and algal growth was observed on the walls of the tank and also around the taps
- Lack of awareness among the villagers leading to washing and bathing near the source leading to source contamination and health issues.

- Open defecation was one of the major issues. Condition of the toilets was bad and unhygienic in Rodopali, Sarasmal, Gare. Most of the people didn't prefer to use the toilets even though it is constructed and operational.
- Water was not stored in clean containers in the house and the storage vessels were also not washed regularly.

VIII. Strategies for Prevention and Control of Health Related Issues

The following strategies are delineated to mitigate the prevailing health related problems.

A. Short term Strategies

- Early detection & management of affected population by surveys
- Development of alternative water supply options
- Delineation of affected areas for early detection and prevention of further exposure
- Development of education and communication materials
- Strengthening of laboratory facilities
- Conduction of training programmes for health personnel
- Establishment of out-patient treatment centre at the Primary health Centre
- Development of collaborative linkages with National and International Agencies
- Water sources having concentrations of fluoride and nitrate above 1.0 and 45 mg/l (i.e. drinking water quality standards as per BIS (10500:2012) respectively must not be used for drinking purposes, whereas sources having arsenic concentration above 10 ppb must be closed. Safe sources available in every village should only be used for drinking purposes

- Hand pumps should be periodically inspected and repaired as platforms were observed to be broken, drainage channels were clogged leading to water accumulation around the hand pumps and consequently leading to microbial contamination
- Awareness campaign for safeguarding water sources against microbial contamination should be undertaken

B. Long term Strategies

- Conduct survey of all ground water sources in the affected area
- Conduction of detailed hydrogeological investigations
- Development of appropriate remedial measures to mitigate the problems
- Development of appropriate measures for supply of safe water
- Training of doctors and health personnel to develop skilled manpower and to disseminate knowledge on arsenicosis and fluorosis
- Development of a surveillance team from grass-root level to district level
- Involvement of mass media and development of Information, Education and Communication (IEC) materials

IX. Recommendations

- Cleaning of the ponds, lakes, dug wells and water supply storage tanks at regular time intervals are necessary and need be made mandatory.
- The hand pumps should be well guarded and the surroundings of the water sources need be kept clean.
- Provision of safe water to the villagers only after proper disinfection

- Suitable insitu treatment technologies can be employed for the treatment and removal of the geogenic contaminants and anthropogenic contaminants.
- Creating awareness among the public with respect to the water usage and maintenance of the water sources needs to be done.
- Regular maintenance of the appurtenances like pipes, taps should be done as the iron and fluoride contaminated water could form scales on the surfaces.
- Regular health's check-up and medication should be provided to the affected.
- Set-up arsenic, and fluoride monitoring cell by PHED
- Monitoring should be headed by an Executive Engineer, Supported by two Assistant Engineers and one Chemist
- The PHCs should also have a monitoring wing for recording arsenic / fluoride affected cases with disease surveillance
- Provision of centralised water treatment plant for a village or 2-3 villages could be a feasible option.
- Providing drinking water through Water ATMs with minimal charges in consultation with CSIR-NEERI.

**Table 1: Sampling Location Details of Water Sources in 14 Villages
in Tamnar Block District Raigarh, Chhattisgarh**

Sl. No.	Village / Location	Water Source	Sample Code	Latitude	Longitude	Date and Time
I	Dolesara					
1.	Main Road Katrapali (Dolesara para)	Hand pump	DOL-1	22° 8.914' N	83°25.507' E	05/09/18 12:30 pm
2.	Adjacent to Main Katrapali (Dolesara para)	Bore Well	DOL-2	22° 08.832' N	83°25.472' E	05/09/18 12:40 pm
3.	Katrapali (Dolesara para)	Dug Well	DOL-3	22° 08.863' N	83°25.487' E	05/09/18 12:45 pm
4.	By the side of the Road, Dolesara basti	Hand pump	DOL-4	22° 08.795' N	83°25.986' E	05/09/18 12:55 pm
5.	Ahead of the road, Dolesara basti	Hand pump	DOL-5	22° 08.769' N	83°26.163' E	05/09/18 01:03 pm
6.	Near Small Temple, Outskirts of Dolesara basti	Pond	DOL-6	22° 08.778' N	83°26.069' E	05/09/18 01:18 pm
II	Pata Para					
7.	Entrance of the Village Pata para	Dug Well	PATA-1	22° 08.628' N	83°26.972' E	05/09/18 01:30 pm
8.	Adjacent to the Village, Pata para	Pond	PATA-2	22° 08.278 ' N	83°27.435' E	05/09/18 01:42 pm
9.	Pata Basti	Hand pump	PATA-3	22° 08.335 ' N	83°27.629' E	05/09/18 01:55 pm
10.	Pata Basti	Hand pump	PATA-4	22° 08.400' N	83°27.748' E	05/09/18 02:04 pm
III	Mudagaon					
11.	Near Entrance of Village	Hand pump	MUD-1	22° 09.039' N	83°28.077' E	05/09/18 02:12 pm
12.	Near Primary School	Hand pump	MUD-2	22° 09.336' N	83°27.970' E	05/09/18 02:22 pm
13.	Near Ratiram Rukhani House H.No. 58	Hand pump	MUD-3	22° 09.373' N	83°28.116' E	05/09/18 02:26 pm

Sl. No.	Village / Location	Water Source	Sample Code	Latitude	Longitude	Date and Time
14.	Outside School	Hand pump	MUD-4	22° 09.436' N	83°28.263' E	05/09/18 02:45 pm
IV	Saraitola					
15.	Near Primary School	Hand pump	SARA-1	22° 09.180' N	83°28.698' E	05/09/18 02:58 pm
16.	Near Storage Tank	Hand pump	SARA-2	22° 09.218' N	83°28.797' E	05/09/18 03:13 pm
17.	About 200m away from Storage Tank	Bore well	SARA-3	22° 09.109' N	83°28.862' E	05/09/18 03:24 pm
18.	Community Storage Tank	Hand pump	SARA-4	22° 09.000' N	83°28.853' E	05/09/18 03:28 pm
V	Kunjemura and Kunjemura Mohalla					
19.	Anganwadi Hukaradipa	Hand pump	KUN-11	22° 07.440' N	83°28.949' E	05/09/18 03:40 pm
20.	Pratamik Shala	Bore well	KUN-12	22° 07.411' N	83°28.930' E	05/09/18 03:47 pm
21.	Opp Boliram Nishad House	Hand pump	KUN-13	22° 07.389' N	83°28.915' E	05/09/18 03:50 pm
22.	Near Shani Temple	Hand pump	KUN-14	22° 07.099' N	83°28.972' E	05/09/18 03:53 pm
23.	Near Nithyanad Nishad House	Hand pump	KUN-15	22° 07.091' N	83°28.575' E	05/09/18 04:00 pm
24.	Kunjemura village	Hand pump	KUN-1	22° 07.913' N	83°28.190' E	05/09/18 03:44 pm
25.	Kunjemura Village near Anganwadi	Hand pump 534543/11	KUN-2	22° 07.913' N	83°28.077' E	05/09/18 03:48 pm
26.	Kunjemura Village near Anganwadi	Hand pump	KUN-3	22° 07.913' N	83°28.018' E	05/09/18 03:54 pm
27.	Kunjemura village	Dug Well	KUN-4	22° 07.913' N	83°28.113' E	05/09/18 04:06 pm
VI	Chitwahi					
28.	In the Premises of Chitwahi High School	Bore well	CHI-1	22° 09.847' N	83°26.146' E	05/09/18 11:00 am
29.	Adjacent to Chitwahi High School	Hand pump No 534530/11	CHI-2	22° 09.847' N	83°26.113' E	05/09/18 11:10 am
30.	Near Community Water Storage	Bore well	CHI-3	22° 09.847' N	83°26.207' E	05/09/18 11:15 am

Sl. No.	Village / Location	Water Source	Sample Code	Latitude	Longitude	Date and Time
	Tank					
31.	In the Premises of Anganwadi	Bore well	CHI-4	22° 09.847' N	83°26.936' E	05/09/18 11:30 am
32.	In the Outskirts of the Village	Pond	CHI-5	22° 09.847' N	83°26.820' E	05/09/18 11:40 am
33.	Near Pump House and Community Bathrooms	Bore well	CHI-6	22° 09.847' N	83°26.044' E	05/09/18 11:54 am
VII	Bhalumuda					
34.	Near the Community Water Tank	Community Water Tank of Bore Well	BHA-1	22° 10.752' N	83°26.572' E	05/09/18 12:10 pm
35.	By Roadside 100 m away from Community Water Tank	Bore well	BHA-2	22° 10.752' N	83°26.518' E	05/09/18 12:15 pm
36.	Outside the School	Bore Well	BHA-3	22° 10.752' N	83°26.604' E	05/09/18 12:30 pm
37.	School Premises	Bore well	BHA-4	22° 10.752' N	83°26.753' E	05/09/18 12:40 pm
VIII	Rodopali					
38.	Inside Anganwadi Premises	Bore well	ROD-1	22° 09.850' N	83°26.784' E	05/09/18 01:01 pm
39.	Near house of Shankar Ratia	Bore well	ROD-2	22° 09.838' N	83°26.817' E	05/09/18 01:10 pm
40.	Outside MLA's House	Bore well	ROD-3	22° 09.813' N	83°26.941' E	05/09/18 01:15 pm
41.	Near Panchayat Bhavan	Bore well	ROD-4	22° 09.800' N	83°26.939' E	05/09/18 01:25 pm
42.	Dongridipa	Bore well	ROD-5	22° 09.676' N	83°26.906' E	05/09/18 01:30 pm
43.	Near Primary school	Bore well	ROD-6	22° 09.737' N	83°26.839' E	05/09/18 01:40 pm
IX	Dholnara					
44.	Near Ananwadi	Bore well	DHO-1	22° 10.349' N	83°27.631' E	05/09/18 02:00 pm
45.	Near NaKa	Bore well	DHO-2	22° 10.424' N	83°27.627' E	05/09/18 02:10 pm
46.	Near Samudaya Bhavan	Bore well	DHO-3	22° 10.383' N	83°27.776' E	05/09/18 02:15 pm
47.	Rathu Gupta House	Bore well	DHO-4	22° 10.360' N	83°27.856' E	05/09/18 02:20 pm

Sl. No.	Village / Location	Water Source	Sample Code	Latitude	Longitude	Date and Time
48.	Outside Jageshwar urav's House	Bore well	DHO-5	22° 10.477' N	83°28.067' E	05/09/18 02:25 pm
49.	Near Sanja Bhagat House	Hand pump	DHO-6	22° 10.475' N	83°28.032' E	05/09/18 02:30 pm
50.	Near Electric Sub Station	Bore well	DHO-7	22° 10.512' N	83°28.210' E	05/09/18 02:35 pm
X	Gare					
51.	Sidar Road	Hand pump	GAR-1	22° 08.742' N	83°29.561' E	05/09/18 02:40 pm
52.	Kanwar Para Dasharat Dansena	Hand pump	GAR-2	22° 08.374' N	83°29.305' E	05/09/18 02:55 pm
53.	Sidar Para Jagsay	Hand pump	GAR-3	22° 08.396' N	83°29.171' E	05/09/18 02:58 pm
54.	Roadside 100 m away from Sidar Para Jagsay	Hand pump	GAR-4	22° 08.386' N	83°29.149' E	05/09/18 03:05 pm
55.	Kalar Para Bahsai	Bore well	GAR-5	22° 08.468' N	83°29.131' E	05/09/18 03:10 pm
56.	Outside Chatur Singh Sidar's House	Hand pump	GAR-6	22° 08.178' N	83°29.328' E	05/09/18 03:15 pm
57.	Outside Sarpanch's House	Bore well	GAR-7	22° 08.116' N	83°29.296' E	05/09/18 03:20 pm
58.	50m away from Sarpanch's House	Hand pump	GAR-8	22° 08.144' N	83°29.241' E	05/09/18 03:30 pm
XI	Tehlrampur					
59.	Near Hetram Bhagat House	Bore well Tank	TEH-1	22°07.163' N	83°29.610' E	06/09/18 11:45 am
60.	Krit Ram Yadav House	Bore well tank	THE-2	22°07.190' N	83°29.651' E	06/09/18 11:51 am
XII	Jhinkabahal					
61.	Bazar area	Bore well and storage	JHI-1	22°06.714' N	83°29.893' E	06/09/18 12:07 pm
62.	Near School	Bore well and storage	JHI-2	22°06.702' N	83°29.831' E	06/09/18 12:20 pm
63.	Near Hanuman Temple	Bore well	JHI-3	22°06.654' N	83°29.992' E	06/09/18 12:23 pm
64.	Near Hanuman Temple	Dug Well	JHI-4	22°06.654' N	83°29.992' E	06/09/18 12:23 pm
65.	About 80-100m on the way to Basti	Bore well	JHI-5	22°06.549' N	83°30.102' E	06/09/18 12:41 pm
66.	Basti	Bore well and storage	JHI-6	22°06.522' N	83°29.931' E	06/09/18 12:45 pm

Sl. No.	Village / Location	Water Source	Sample Code	Latitude	Longitude	Date and Time
XIII	Libra					
67.	Balpur	Bore well and storage	LIB-1	22°06.476' N	83°30.287' E	06/09/18 12:53 pm
68.	Basti	Hand pump	LIB-2	22°06.463' N	83°30.434' E	06/09/18 12:58 pm
69.	Inside the School Premises	Hand pump	LIB-3	22°06.461' N	83°30.644' E	06/09/18 01:05 pm
70.	Inside the School Premises	Bore well	LIB-3A	22°06.461' N	83°30.644' E	06/09/18 01:05 pm
71.	Patel para	Bore well and storage	LIB-4	22°06.450' N	83°30.824' E	06/09/18 01:24 pm
72.	Samblai Chowk	Bore well	LIB-5	22°06.517' N	83°30.695' E	06/09/18 01:29 pm
73.	High School Mohalla	Bore well	LIB-6	22°06.781' N	83°30.671' E	06/09/18 01:46 pm
XIV	Sarasmal (Kosampalli)					
74.	Near the Main Entrance of the Village	Pond	SARL-1	22°07.942' N	83°30.727' E	06/09/18 01:53 pm
75.	Patel Mohalla	Bore well	SARL-2	22°07.964' N	83°30.601' E	06/09/18 02:01 pm
76.	On the Main Road	Dug Well	SARL-3	22°07.971' N	83°30.429' E	06/09/18 02:11 pm
77.	Near Community Storage	Bore Well	SARL-4	22°07.970' N	83°30.475' E	06/09/18 02:15 pm
78.	At Rear End of the Village near Kaccha Road	Pond	SARL-5	22°07.911' N	83°30.215' E	06/09/18 02:18 pm
79.	Inside High School Premises	Bore well	SARL-6	22°07.890' N	83°30.458' E	06/09/18 02:30 pm
80.	Near school	Dug Well	SARL-7	22°07.890' N	83°30.458' E	06/09/18 02:36 pm

Table 2: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Dolesara, District Raigarh (C.G)

Sl. No.	Sample Code	DOL-1	DOL-2	DOL-3	DOL-4	DOL-5	DOL-6	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter							
1.	pH	6.6	6.6	6.9	6.8	6.9	<u>5.9</u>	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	141	437	306	312	154	230	-
3.	TDS (mg/L)	85	262	184	187	92	138	500-2000
4.	Turbidity (NTU)	75	2	6	20	60	27	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	148	220	92	160	76	60	200-600
6.	Total Hardness as CaCO_3 (mg/L)	120	172	52	140	48	32	200-600
7.	Calcium as Ca^{2+} (mg/L)	34	34	16	18	5	5	75-200
8.	Magnesium as Mg^{2+} (mg/L)	11	23	6	23	9	7	30-100
9.	Chloride as Cl^- (mg/L)	10	24	50	14	8	18	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	35	15	5	40	26	66	200-400
11.	Nitrate as NO_3^- (mg/L)	0.8	0.2	35	ND	0.3	0.8	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.01	0.01	0.02	0.01	0.01	0.1	-
13.	Sodium as Na^+ (mg/L)	6	24	32	13	4	23	-
14.	Potassium as K^+ (mg/L)	8	15	20	10	4	5	-
15.	Fluoride as F^- (mg/L)	0.3	0.3	0.1	0.5	0.4	0.3	1.0-1.5
16.	TC CFU/100ml	4	-	-	0	-	4500	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	0	4	40	0	2	2400	Shall not be detectable in any 100ml Sample

Table 3: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Pata, District Raigarh (C.G)

Sl. No.	Sample Code	PATA-1	PATA-2	PATA-3	PATA-4	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter					
1.	pH	<u>6.4</u>	<u>6.1</u>	<u>6.4</u>	6.9	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	265	71	285	468	-
3.	TDS (mg/L)	159	42	171	281	500-2000
4.	Turbidity (NTU)	5	4	1	<u>12</u>	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	96	80	136	232	200-600
6.	Total Hardness as CaCO_3 (mg/L)	120	24	100	148	200-600
7.	Calcium as Ca^{2+} (mg/L)	34	8	18	24	75-200
8.	Magnesium as Mg^{2+} (mg/L)	9	4	13	21	30-100
9.	Chloride as Cl^- (mg/L)	30	12	20	30	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	16	41	19	29	200-400
11.	Nitrate as NO_3^- (mg/L)	<u>53</u>	0.7	0.2	0.2	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.1	0.01	0.02	0.01	-
13.	Sodium as Na^+ (mg/L)	10	10	13	39	-
14.	Potassium as K^+ (mg/L)	14	2	24	20	-
15.	Fluoride as F^- (mg/L)	0.2	0.3	1.3	1.2	1.0-1.5
16.	TC CFU/100ml	-	-	-	-	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	160	0	1	16	Shall not be detectable in any 100ml Sample

Table 4: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Mudagaon, District Raigarh (C.G)

Sl. No.	Sample Code	MUD-1	MUD-2	MUD-3	MUD-4	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter					
1.	pH	6.9	<u>6.3</u>	6.6	6.9	6.5-8.5
2.	EC ($\mu\text{S}/\text{cm}$)	324	293	274	307	-
3.	TDS (mg/L)	194	176	164	184	500-2000
4.	Turbidity (NTU)	<u>6</u>	<u>60</u>	<u>25</u>	3	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	172	116	140	152	200-600
6.	Total Hardness as CaCO_3 (mg/L)	128	120	120	52	200-600
7.	Calcium as Ca^{2+} (mg/L)	14	18	24	5	75-200
8.	Magnesium as Mg^{2+} (mg/L)	22	18	14	10	30-100
9.	Chloride as Cl^- (mg/L)	24	30	24	20	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	31	43	36	40	200-400
11.	Nitrate as NO_3^- (mg/L)	0.3	0.1	0.4	0.2	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.02	0.02	0.01	0.01	-
13.	Sodium as Na^+ (mg/L)	25	16	19	54	-
14.	Potassium as K^+ (mg/L)	13	7	9	8	-
15.	Fluoride as F^- (mg/L)	0.5	0.4	0.2	<u>2.3</u>	1.0-1.5
16.	TC CFU/100ml	50	-	-	600	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	8	8	0	4	Shall not be detectable in any 100ml Sample

Table 5: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Saraitola, District Raigarh (C.G)

Sl. No.	Sample Code	SARA-1	SARA-2	SARA-3	SARA-4	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter					
1.	pH	<u>6.1</u>	<u>6.0</u>	<u>5.7</u>	<u>6.1</u>	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	253	644	391	417	-
3.	TDS (mg/L)	152	386	235	250	500-2000
4.	Turbidity (NTU)	<u>8</u>	<u>380</u>	<u>7</u>	<u>55</u>	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	100	108	68	144	200-600
6.	Total Hardness as CaCO_3 (mg/L)	80	112	120	116	200-600
7.	Calcium as Ca^{2+} (mg/L)	16	37	16	11	75-200
8.	Magnesium as Mg^{2+} (mg/L)	10	5	19	21	30-100
9.	Chloride as Cl^- (mg/L)	36	24	46	46	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	2	200	55	33	200-400
11.	Nitrate as NO_3^- (mg/L)	15	0.1	0.1	3.4	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.01	0.02	0.01	0.02	-
13.	Sodium as Na^+ (mg/L)	23	59	32	49	-
14.	Potassium as K^+ (mg/L)	5	12	14	22	-
15.	Fluoride as F^- (mg/L)	0.7	<u>4.7</u>	<u>2.6</u>	<u>2.6</u>	1.0-1.5
16.	TC CFU/100ml	50	-	-	600	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	8	8	0	4	Shall not be detectable in any 100ml Sample

Table 6: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Kunjemura Mohalla, District Raigarh (C.G)

Sl. No.	Sample Code	KUN-11	KUN-12	KUN-13	KUN-14	KUN-15	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter						
1.	pH	7.5	6.9	7.1	6.6	5.7	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	496	325	541	336	149	-
3.	TDS (mg/L)	298	195	324	202	89	500-2000
4.	Turbidity (NTU)	3	<u>6</u>	2	2	<u>51</u>	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	232	140	268	172	48	200-600
6.	Total Hardness as CaCO_3 (mg/L)	200	104	248	104	52	200-600
7.	Calcium as Ca^{2+} (mg/L)	22	18	56	11	3	75-200
8.	Magnesium as Mg^{2+} (mg/L)	35	14	26	18	11	30-100
9.	Chloride as Cl^- (mg/L)	38	30	30	30	24	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	1	9	2	4	8	200-400
11.	Nitrate as NO_3^- (mg/L)	0.1	1.0	1.5	0.1	0.2	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.02	0.02	0.02	0.01	0.02	-
13.	Sodium as Na^+ (mg/L)	40	22	17	21	9	-
14.	Potassium as K^+ (mg/L)	21	38	9	32	2	-
15.	Fluoride as F^- (mg/L)	0.4	0.3	0.3	0.3	0.1	1.0-1.5
16.	TC CFU/100ml	-	-	-	-	6	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	32	210	0	0	0	Shall not be detectable in any 100ml Sample

Table 6a: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Kunjemura, District Raigarh (C.G)

Sl. No.	Sample Code	KUN-1	KUN-2	KUN-3	KUN-4	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter					
1.	pH	6.5	7.2	6.8	6.9	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	284	352	337	669	-
3.	TDS (mg/L)	170	211	202	401	500-2000
4.	Turbidity (NTU)	<u>90</u>	<u>22</u>	<u>8</u>	3	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	136	180	128	196	200-600
6.	Total Hardness as CaCO_3 (mg/L)	100	140	84	256	200-600
7.	Calcium as Ca^{2+} (mg/L)	8	16	18	50	75-200
8.	Magnesium as Mg^{2+} (mg/L)	19	24	10	32	30-100
9.	Chloride as Cl^- (mg/L)	28	16	30	100	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	26	28	14	60	200-400
11.	Nitrate as NO_3^- (mg/L)	0.1	0.2	0.1	<u>120</u>	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.02	ND	0.01	0.01	-
13.	Sodium as Na^+ (mg/L)	19	11	16	53	-
14.	Potassium as K^- (mg/L)	21	17	24	40	-
15.	Fluoride as F^- (mg/L)	0.6	0.6	0.4	0.2	1.0-1.5
16.	TC CFU/100ml	0	-	1	-	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	0	10	0	149	Shall not be detectable in any 100ml Sample

Table 7: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Chitwahi, District Raigarh (C.G)

Sl. No.	Sample Code	CHI-1	CHI-2	CHI-3	CHI-4	CHI-5	CHI-6	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter							
1.	pH	7.3	7.1	6.8	6.9	6.7	6.7	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	453	496	494	828	134	470	-
3.	TDS (mg/L)	272	297	296	497	80	282	500-2000
4.	Turbidity (NTU)	2	0.9	1	4	<u>20</u>	2	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	204	172	216	284	60	228	200-600
6.	Total Hardness as CaCO_3 (mg/L)	208	200	192	280	48	164	200-600
7.	Calcium as Ca^{2+} (mg/L)	32	43	29	40	3	18	75-200
8.	Magnesium as Mg^{2+} (mg/L)	31	22	29	43	10	29	30-100
9.	Chloride as Cl^- (mg/L)	48	38	32	66	22	24	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	19	36	20	79	5	25	200-400
11.	Nitrate as NO_3^- (mg/L)	0.5	<u>50</u>	0.2	0.2	0.6	0.3	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.03	0.03	0.02	0.02	0.02	0.02	-
13.	Sodium as Na^+ (mg/L)	24	27	36	22	19	41	-
14.	Potassium as K^+ (mg/L)	8	9	20	32	4	20	-
15.	Fluoride as F^- (mg/L)	0.8	0.4	0.4	0.3	0.2	0.4	1.0-1.5
16.	TC CFU/100ml	-	650	70	-	-	52	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	-	0	35	5	600	41	Shall not be detectable in any 100ml Sample

Table 8: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Bhalumuda, District Raigarh (C.G)

Sl. No.	Sample Code	BHA-1	BHA-2	BHA-3	BHA-4	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter					
1.	pH	<u>5.4</u>	7.1	6.9	7.4	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	176	494	427	449	-
3.	TDS (mg/L)	105	296	256	270	500-2000
4.	Turbidity (NTU)	2	1	3	3	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	60	232	188	208	200-600
6.	Total Hardness as CaCO_3 (mg/L)	72	80	168	180	200-600
7.	Calcium as Ca^{2+} (mg/L)	6	6	30	24	75-200
8.	Magnesium as Mg^{2+} (mg/L)	13	15	22	29	30-100
9.	Chloride as Cl^- (mg/L)	40	16	56	22	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	3	6	4	16	200-400
11.	Nitrate as NO_3^- (mg/L)	31	0.2	0.3	1.4	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.13	0.02	0.03	0.1	-
13.	Sodium as Na^+ (mg/L)	18	53	22	31	-
14.	Potassium as K^+ (mg/L)	5	25	20	19	-
15.	Fluoride as F^- (mg/L)	0.04	0.6	0.5	0.5	1.0-1.5
16.	TC CFU/100ml	97	-	-	8900	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	130	25	105	900	Shall not be detectable in any 100ml Sample

Table 9: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Rodopali, District Raigarh (C.G)

Sl. No.	Sample Code	ROD-1	ROD-2	ROD-3	ROD-4	ROD-5	ROD-6	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter							
1.	pH	7.0	6.5	7.2	6.8	6.7	7.0	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	620	267	525	524	325	577	-
3.	TDS (mg/L)	372	160	315	314	195	346	500-2000
4.	Turbidity (NTU)	4	4	2	1	1	3	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	236	124	232	192	140	240	200-600
6.	Total Hardness as CaCO_3 (mg/L)	252	132	196	200	148	208	200-600
7.	Calcium as Ca^{2+} (mg/L)	30	19	27	27	22	30	75-200
8.	Magnesium as Mg^{2+} (mg/L)	42	20	31	32	22	32	30-100
9.	Chloride as Cl^- (mg/L)	34	10	28	26	20	20	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	24	19	3	6	12	7	200-400
11.	Nitrate as NO_3^- (mg/L)	0.6	0.4	0.3	1.6	4.5	1.8	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.1	0.1	0.1	0.03	0.03	0.02	-
13.	Sodium as Na^+ (mg/L)	39	11	33	25	18	40	-
14.	Potassium as K^+ (mg/L)	29	9	25	30	12	24	-
15.	Fluoride as F^- (mg/L)	0.5	0.5	0.5	0.8	0.5	0.5	1.0-1.5
16.	TC CFU/100ml	99	-	45	-	-	-	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	0	0	0	50	0	-	Shall not be detectable in any 100ml Sample

Table 10: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Dholnara, District Raigarh (C.G)

Sl. No.	Sample Code	DHO-1	DHO-2	DHO-3	DHO-4	DHO-5	DHO-6	DHO-7	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter								
1.	pH	6.6	6.5	6.8	6.5	6.6	<u>5.8</u>	<u>5.8</u>	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	226	297	923	255	239	231	206	-
3.	TDS (mg/L)	135	178	554	153	143	139	123	500-2000
4.	Turbidity (NTU)	4	2	2	<u>8</u>	0.4	<u>8</u>	4	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	76	100	164	100	112	92	108	200-600
6.	Total Hardness as CaCO_3 (mg/L)	88	124	204	116	104	88	92	200-600
7.	Calcium as Ca^{2+} (mg/L)	19	21	34	16	24	8	13	75-200
8.	Magnesium as Mg^{2+} (mg/L)	10	17	29	18	11	16	14	30-100
9.	Chloride as Cl^- (mg/L)	24	100	2	22	3	6	6	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	36	19	62	33	3	6	6	200-400
11.	Nitrate as NO_3^- (mg/L)	1	18	<u>121</u>	0.6	2.5	16	0.2	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.02	0.04	0.02	0.1	0.01	0.02	0.02	-
13.	Sodium as Na^+ (mg/L)	10	11	41	9	4	16	10	-
14.	Potassium as K^+ (mg/L)	8	11	112	9	3	5	7	-
15.	Fluoride as F^- (mg/L)	0.3	0.4	0.7	0.7	0.2	0.1	0.5	1.0-1.5
16.	TC CFU/100ml	4	-	-	0	-	4500	-	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	0	4	40	0	2	2400	0	Shall not be detectable in any 100ml Sample

Table 11: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Gare District Raigarh (C.G)

Sl.No.	Sample Code	GAR-1	GAR -2	GAR -3	GAR -4	GAR -5	GAR -6	GAR-7	GAR-8	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter									
1.	pH	<u>5.4</u>	<u>6.0</u>	<u>6.2</u>	6.5	7	6.4	6.7	6.4	6.5-8.5
2.	EC (µS/cm)	120	219	361	209	744	273	357	353	-
3.	TDS (mg/L)	72	131	217	125	446	164	214	212	500-2000
4.	Turbidity (NTU)	3	<u>26</u>	1	3	3	4	3	<u>22</u>	1-5
5.	Total alkalinity as CaCO ₃ (mg/L)	44	84	120	144	236	120	144	136	200-600
6.	Total Hardness as CaCO ₃ (mg/L)	52	80	164	100	260	88	124	112	200-600
7.	Calcium as Ca ²⁺ (mg/L)	3	19	40	10	50	11	18	16	75-200
8.	Magnesium as Mg ²⁺ (mg/L)	11	8	15	18	33	14	19	17	30-100
9.	Chloride as Cl ⁻ (mg/L)	16	26	50	22	78	22	40	44	250-1000
10.	Sulphate as SO ₄ ²⁻ (mg/L)	8	8	33	5	66	14	10	7	200-400
11.	Nitrate as NO ₃ ⁻ (mg/L)	11	0.4	42	ND	6.2	0.2	0.2	0.2	45
12.	Phosphate as PO ₄ ⁻² (mg/L)	0.01	0.01	0.1	0.03	0.03	0.03	0.02	0.02	-
13.	Sodium as Na ⁺ (mg/L)	9	14	25	20	30	23	23	20	-
14.	Potassium as K ⁺ (mg/L)	5	9	18	17	39	20	31	30	-
15.	Fluoride as F ⁻ (mg/L)	0.2	0.5	0.1	1.2	0.9	1.3	0.6	0.4	1.0-1.5
16.	TC CFU/100ml	-	-	90	-	-	-	-	109	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	1	0	60	0	2000	116	5	10	Shall not be detectable in any 100ml Sample

Table 12: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Tehlirampur District Raigarh (C.G)

Sl.No.	Sample Code	TEH-1	TEH-2	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter			
1.	pH	6.4	6.7	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	839	405	-
3.	TDS (mg/L)	504	243	500-2000
4.	Turbidity (NTU)	3	4	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	136	156	200-600
6.	Total Hardness as CaCO_3 (mg/L)	224	64	200-600
7.	Calcium as Ca^{2+} (mg/L)	16	10	75-200
8.	Magnesium as Mg^{2+} (mg/L)	44	10	30-100
9.	Chloride as Cl^- (mg/L)	100	60	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	81	27	200-400
11.	Nitrate as NO_3^- (mg/L)	<u>126</u>	0.4	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.01	ND	-
13.	Sodium as Na^+ (mg/L)	47	52	-
14.	Potassium as K^+ (mg/L)	50	31	-
15.	Fluoride as F^- (mg/L)	0.1	0.4	1.0-1.5
16.	TC CFU/100ml	104	-	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	58	0	Shall not be detectable in any 100ml Sample

Table 13: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Jhinkabahal District Raigarh (C.G)

Sl.No.	Sample Code	JHI-1	JHI - 2	JHI - 3	JHI - 4	JHI -5	JHI -6	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter							
1.	pH	<u>6.2</u>	<u>5.3</u>	<u>6.2</u>	<u>6.1</u>	6.7	<u>5.8</u>	6.5-8.5
2.	EC (µS/cm)	188	234	229	710	350	158	-
3.	TDS (mg/L)	113	141	137	426	210	95	500-2000
4.	Turbidity (NTU)	3	0.4	0.9	2.5	0.5	5.5	1-5
5.	Total alkalinity as CaCO ₃ (mg/L)	100	48	68	152	128	76	200-600
6.	Total Hardness as CaCO ₃ (mg/L)	80	168	120	152	108	64	200-600
7.	Calcium as Ca ²⁺ (mg/L)	11	34	24	32	18	11	75-200
8.	Magnesium as Mg ²⁺ (mg/L)	12	20	14	17	15	9	30-100
9.	Chloride as Cl ⁻ (mg/L)	16	32	46	26	30	28	250-1000
10.	Sulphate as SO ₄ ²⁻ (mg/L)	5	22	16	61	16	10	200-400
11.	Nitrate as NO ₃ ⁻ (mg/L)	0.2	21	15	<u>79</u>	7.5	0.6	45
12.	Phosphate as PO ₄ ⁻² (mg/L)	0.02	0.03	0.04	0.1	0.02	0.04	-
13.	Sodium as Na ⁺ (mg/L)	8	20	23	36	24	14	-
14.	Potassium as K ⁻ (mg/L)	9	5	16	64	24	6	-
15.	Fluoride as F ⁻ (mg/L)	0.3	0.2	0.3	0.5	0.4	0.3	1.0-1.5
16.	TC CFU/100ml	-	298	-	-	-	230	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	54	193	20	10	0	186	Shall not be detectable in any 100ml Sample

Table 14: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Libra District Raigarh (C.G)

Sl. No.	Sample Code	LIB-1	LIB - 2	LIB - 3	LIB - 3a	LIB - 4	LIB - 5	LIB - 6	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter								
1.	pH	6.4	6.3	7.3	6.9	6.7	6.4	5.5	6.5-8.5
2.	EC ($\mu\text{S}/\text{cm}$)	220	377	397	375	281	194	181	-
3.	TDS (mg/L)	132	226	238	225	168	116	108	500-2000
4.	Turbidity (NTU)	8	12	3	4	16	15	0.8	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	92	112	148	104	128	120	60	200-600
6.	Total Hardness as CaCO_3 (mg/L)	92	140	108	104	124	100	44	200-600
7.	Calcium as Ca^{2+} (mg/L)	19	16	13	18	19	22	6	75-200
8.	Magnesium as Mg^{2+} (mg/L)	11	24	18	14	18	11	7	30-100
9.	Chloride as Cl^- (mg/L)	26	80	46	48	34	12	30	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	7	20	3	18	5	3	7	200-400
11.	Nitrate as NO_3^- (mg/L)	0.3	0.1	ND	12.4	0.3	ND	41	45
12.	Phosphate as PO_4^{3-} (mg/L)	0.02	0.02	0.01	0.04	0.02	0.02	0.1	-
13.	Sodium as Na^+ (mg/L)	10	23	35	31	11	10	26	-
14.	Potassium as K^+ (mg/L)	5	9	12	31	8	6	9	-
15.	Fluoride as F^- (mg/L)	0.3	0.3	0.2	0.3	0.2	0.3	0.3	1.0-1.5
16.	TC CFU/100ml	-	-	42	-	126	-	30-	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	0	0	40	0	3	4	1`	Shall not be detectable in any 100ml Sample

Table 15: Physico-Chemical and Bacteriological Quality of Ground Water Sources in Village Sarasmal, District Raigarh (C.G)

Sl. No.	Sample Code	SARL-1	SARL-2	SARL-3	SARL-4	SARL-5	SARL-6	SARL-7	BIS : 10500-2012 Desirable/ Permissible limit
	Parameter								
1.	pH	6.9	<u>5.5</u>	6.3	<u>5.9</u>	6.4	<u>5.9</u>	6.5	6.5-8.5
2.	EC ($\mu\text{S/cm}$)	113	333	564	346	579	268	613	-
3.	TDS (mg/L)	68	200	338	207	348	161	368	500-2000
4.	Turbidity (NTU)	2.5	1.6	0.6	2.6	2	<u>20</u>	3	1-5
5.	Total alkalinity as CaCO_3 (mg/L)	52	40	96	48	52	120	92	200-600
6.	Total Hardness as CaCO_3 (mg/L)	40	120	140	112	260	108	160	200-600
7.	Calcium as Ca^{2+} (mg/L)	5	19	27	14	27	13	27	75-200
8.	Magnesium as Mg^{2+} (mg/L)	7	17	17	18	46	18	22	30-100
9.	Chloride as Cl^- (mg/L)	10	36	40	36	40	32	34	250-1000
10.	Sulphate as SO_4^{2-} (mg/L)	12	18	41	29	281	26	55	200-400
11.	Nitrate as NO_3^- (mg/L)	1.2	<u>92</u>	<u>133</u>	<u>82</u>	6.9	1	4	45
12.	Phosphate as PO_4^{2-} (mg/L)	0.04	0.1	0.1	0.02	0.1	0.01	0.1	-
13.	Sodium as Na^+ (mg/L)	11	24	34	30	20	19	30	-
14.	Potassium as K^+ (mg/L)	8	35	64	34	16	16	70	-
15.	Fluoride as F^- (mg/L)	0.2	0.1	0.1	0.1	0.5	0.3	0.1	1.0-1.5
16.	TC CFU/100ml	-	388	-	-	-	430	408	Shall not be detectable in any 100ml Sample
17.	FC CFU/100ml	39	44	140	7	5	49	300	Shall not be detectable in any 100ml Sample

Table 16: Water Quality of Ground Water Sources in 14 Villages of Tamnar Block, District Raigarh (C.G) (Metals)

Sr. No.	Sample code	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
BIS Limit (ppm)		0.01	0.003	0.05	-	0.05-1.5	1.0	0.10-0.30	0.02	0.01	5.0-15
ICP detection Limit (ppm)		0.007	0.0001	0.01		0.0004	0.0003	0.0001	0.005	0.009	0.001
I	Dolesara										
1.	DOL-1	<u>0.8</u>	0.01	0.03	ND	0.004	<u>2</u>	0.2	0.003	<u>0.04</u>	0.2
2.	DOL-2	<u>0.3</u>	0.003	0.008	ND	ND	0.3	<u>0.5</u>	0.01	0.01	0.002
3.	DOL-3	<u>0.3</u>	0.003	0.005	ND	ND	0.1	0.01	BDL	0.004	0.02
4.	DOL-4	<u>0.3</u>	0.003	0.005	ND	ND	0.7	0.07	ND	0.003	0.003
5.	DOL-5	<u>0.2</u>	0.002	0.005	ND	ND	<u>3</u>	0.3	BDL	0.004	0.09
6.	DOL-6	<u>0.3</u>	0.002	0.003	ND	ND	0.1	0.04	BDL	0.002	0.005
II	Pata										
7.	PATA-1	<u>0.1</u>	0.001	0.004	0.002	ND	ND	0.01	BDL	0.003	0.012
8.	PATA-2	<u>0.1</u>	0.001	BDL	0.001	BDL	ND	0.01	BDL	0.001	0.005
9.	PATA-3	<u>0.07</u>	0.001	BDL	0.002	ND	ND	0.2	BDL	0.003	10.5
10.	PATA-4	<u>0.05</u>	BDL	BDL	ND	BDL	0.3	0.2	BDL	0.003	0.2
III	Mudagaon										
11.	MUD-1	<u>0.04</u>	BDL	BDL	0.1	ND	ND	0.3	<u>0.1</u>	0.001	1.3
12.	MUD-2	<u>0.03</u>	BDL	BDL	ND	ND	<u>8</u>	0.3	BDL	0.003	0.06
13.	MUD-3	<u>0.03</u>	BDL	BDL	ND	ND	0.2	<u>0.8</u>	BDL	0.002	0.03
14.	MUD-4	<u>0.04</u>	BDL	BDL	0.001	ND	ND	0.1	BDL	0.002	0.3
IV	Saraitola										

Sr. No.	Sample code	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
BIS Limit (ppm)		0.01	0.003	0.05	-	0.05-1.5	1.0	0.10-0.30	0.02	0.01	5.0-15
ICP detection Limit (ppm)		0.007	0.0001	0.01		0.0004	0.0003	0.0001	0.005	0.009	0.001
15.	SARA-1	<u>0.02</u>	BDL	BDL	ND	ND	<u>7</u>	0.2	0.05	0.002	1
16.	SARA-2	<u>0.03</u>	ND	0.03	ND	ND	<u>32</u>	<u>0.9</u>	0.04	0.003	0.08
17.	SARA-3	<u>0.03</u>	ND	0.01	ND	ND	<u>14</u>	0.5	<u>0.2</u>	0.003	0.3
18.	SARA-4	<u>0.02</u>	ND	0.01	ND	ND	<u>16</u>	<u>0.9</u>	<u>0.06</u>	0.002	17
V	Kunjemura										
19.	KUN-1	0.01	ND	BDL	ND	ND	1.0	<u>0.5</u>	BDL	0.003	0.4
20.	KUN-2	0.01	BDL	ND	ND	ND	0.07	0.1	ND	0.002	0.07
21.	KUN-3	<u>0.02</u>	BDL	BDL	ND	ND	<u>2</u>	0.1	BDL	0.003	0.3
22.	KUN-4	0.01	BDL	0.01	0.001	ND	ND	0.01	BDL	0.005	0.01
23.	KUN-11	BDL	ND	BDL	ND	ND	0.2	0.06	BDL	ND	0.3
24.	KUN-12	0.005	ND	ND	0.0003	ND	ND	0.06	ND	ND	0.008
25.	KUN-13	BDL	BDL	ND	0.002	ND	ND	0.09	BDL	ND	0.8
26.	KUN-14	ND	ND	ND	ND	ND	0.8	0.02	BDL	ND	1.2
27.	KUN-15	ND	ND	0.01	ND	ND	<u>30</u>	0.3	0.01	ND	0.5
VI	Chitwahi										
28.	CHI-1	0.001	ND	ND	0.003	ND	ND	0.08	BDL	0.003	0.02
29.	CHI-2	0.004	ND	ND	0.002	0.01	ND	BDL	BDL	0.002	0.54
30.	CHI-3	0.004	ND	ND	0.01	ND	ND	0.01	0.01	0.003	0.03
31.	CHI-4	0.004	ND	ND	0.004	ND	ND	BDL	BDL	0.002	0.06
32.	CHI-5	0.002	ND	ND	0.003	ND	ND	0.06	BDL	0.0005	0.008
33.	CHI-6	0.001	ND	ND	0.004	ND	ND	0.01	ND	0.002	0.009

Sr. No.	Sample code	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
BIS Limit (ppm)		0.01	0.003	0.05	-	0.05-1.5	1.0	0.10-0.30	0.02	0.01	5.0-15
ICP detection Limit (ppm)		0.007	0.0001	0.01		0.0004	0.0003	0.0001	0.005	0.009	0.001
VII.	Bhalumuda										
34.	BHA-1	0.002	ND	ND	0.005	0.001	ND	BDL	0.01	0.005	0.09
35.	BHA-2	0.001	BDL	ND	0.003	ND	ND	BDL	BDL	0.002	0.003
36.	BHA-3	0.003	ND	ND	0.003	ND	ND	BDL	BDL	0.003	0.01
37.	BHA-4	0.002	BDL	ND	0.003	ND	ND	0.01	BDL	0.002	0.002
VIII.	Rodopali										
38.	ROD-1	0.003	ND	ND	0.02	ND	ND	0.01	0.02	0.002	0.009
39.	ROD-2	0.003	ND	ND	0.05	ND	ND	0.04	<u>0.06</u>	0.004	0.03
40.	ROD-3	0.002	ND	BDL	0.002	ND	0.05	<u>0.6</u>	<u>0.11</u>	0.01	0.03
41.	ROD-4	0.003	BDL	ND	0.009	ND	ND	0.06	0.009	0.003	0.01
42.	ROD-5	0.004	BDL	BDL	0.002	ND	0.01	0.03	BDL	0.004	0.02
43.	ROD-6	0.004	ND	ND	0.006	ND	ND	0.02	0.008	0.002	0.02
IX.	Dholnara										
44.	DHO-1	<u>0.7</u>	BDL	0.03	ND	ND	1.0	0.1	0.05	0.05	0.12
45.	DHO-2	<u>0.2</u>	0.002	0.01	ND	0.02	1.0	0.1	0.01	0.007	0.23
46.	DHO-3	<u>0.2</u>	0.001	0.01	ND	ND	0.2	ND	BDL	0.0001	0.04
47.	DHO-4	<u>0.3</u>	0.001	BDL	ND	ND	0.4	0.1	BDL	ND	0.006
48.	DHO-5	<u>0.2</u>	0.001	BDL	ND	ND	0.08	BDL	BDL	ND	0.01
49.	DHO-6	<u>0.2</u>	0.004	BDL	ND	0.003	0.4	0.02	BDL	ND	16
50.	DHO-7	<u>0.1</u>	0.001	BDL	ND	ND	0.1	0.05	0.01	ND	0.03

Sr. No.	Sample code	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
BIS Limit (ppm)		0.01	0.003	0.05	-	0.05-1.5	1.0	0.10-0.30	0.02	0.01	5.0-15
ICP detection Limit (ppm)		0.007	0.0001	0.01		0.0004	0.0003	0.0001	0.005	0.009	0.001
X.	Gare										
51.	GAR-1	<u>0.1</u>	BDL	BDL	ND	0.001	1.0	0.1	0.02	ND	0.62
52.	GAR-2	<u>0.1</u>	BDL	BDL	ND	ND	<u>3</u>	0.3	BDL	ND	0.01
53.	GAR-3	<u>0.1</u>	BDL	BDL	ND	ND	<u>2</u>	0.07	BDL	ND	0.06
54.	GAR-4	<u>0.03</u>	BDL	BDL	ND	ND	1.0	0.05	ND	ND	0.008
55.	GAR-5	<u>0.04</u>	BDL	BDL	ND	ND	<u>5</u>	0.07	BDL	ND	0.009
56.	GAR-6	<u>0.02</u>	BDL	BDL	ND	ND	<u>2</u>	0.09	0.02	ND	0.01
57.	GAR-7	<u>0.02</u>	BDL	ND	ND	ND	0.1	0.07	ND	ND	0.003
58.	GAR-8	0.01	BDL	BDL	ND	ND	<u>2</u>	0.08	BDL	ND	0.75
XI.	Tehlirampur										
59.	TEH-1	0.01	BDL	ND	0.002	ND	ND	0.2	BDL	0.001	0.01
60.	TEH-2	<u>0.02</u>	BDL	BDL	0.02	ND	ND	0.03	0.03	0.002	0.08
XII.	Jhinkabahal										
61.	JHI-1	0.01	ND	ND	0.002	ND	ND	0.2	BDL	0.004	0.005
62.	JHI-2	0.01	ND	BDL	0.003	ND	ND	0.01	0.009	0.002	0.02
63.	JHI-3	0.01	ND	BDL	0.005	ND	ND	<u>3</u>	0.008	0.003	0.04
64.	JHI-4	0.01	ND	BDL	0.003	ND	ND	BDL	BDL	0.001	0.02
65.	JHI-5	0.01	ND	ND	0.003	ND	ND	0.03	BDL	0.002	0.08
66.	JHI-6	0.01	ND	ND	0.005	ND	ND	<u>26</u>	BDL	0.008	0.01
XIII.	Libra										
67.	LIB-1	0.01	ND	BDL	ND	ND	<u>2</u>	0.08	BDL	0.004	0.02

Sr. No.	Sample code	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
BIS Limit (ppm)		0.01	0.003	0.05	-	0.05-1.5	1.0	0.10-0.30	0.02	0.01	5.0-15
ICP detection Limit (ppm)		0.007	0.0001	0.01		0.0004	0.0003	0.0001	0.005	0.009	0.001
68.	LIB-2	0.01	ND	BDL	ND	ND	0.3	0.3	0.01	0.001	0.008
69.	LIB-3	BDL	ND	ND	ND	ND	ND	0.04	BDL	0.0009	0.004
70.	LIB-3a	0.01	ND	ND	ND	ND	0.02	0.01	BDL	0.003	0.01
71.	LIB-4	0.01	ND	ND	0.004	ND	ND	0.2	BDL	0.004	0.01
72.	LIB-5	BDL	ND	BDL	ND	ND	6	0.1	BDL	0.005	0.02
73.	LIB-6	BDL	BDL	BDL	0.001	ND	ND	0.04	BDL	0.004	0.02
XIV.	Sarasmal										
74.	SARL-1	BDL	ND	ND	0.002	ND	ND	BDL	BDL	0.001	0.001
75.	SARL-2	BDL	BDL	0.05	0.03	BDL	ND	0.2	0.1	0.002	0.1
76.	SARL-3	0.01	BDL	BDL	0.003	ND	ND	BDL	BDL	0.001	0.07
77.	SARL-4	BDL	BDL	BDL	0.03	BDL	ND	0.2	0.1	0.002	0.1
78.	SARL-5	0.005	ND	ND	0.005	ND	ND	0.4	0.03	0.001	0.03
79.	SARL-6	0.003	ND	0.001	ND	ND	1.0	0.1	BDL	0.003	0.07
80.	SARL-7	0.004	ND	BDL	0.003	ND	ND	BDL	BDL	0.0007	0.01

Notes: BDL-Below Detection Limit; ND-Not Detected

