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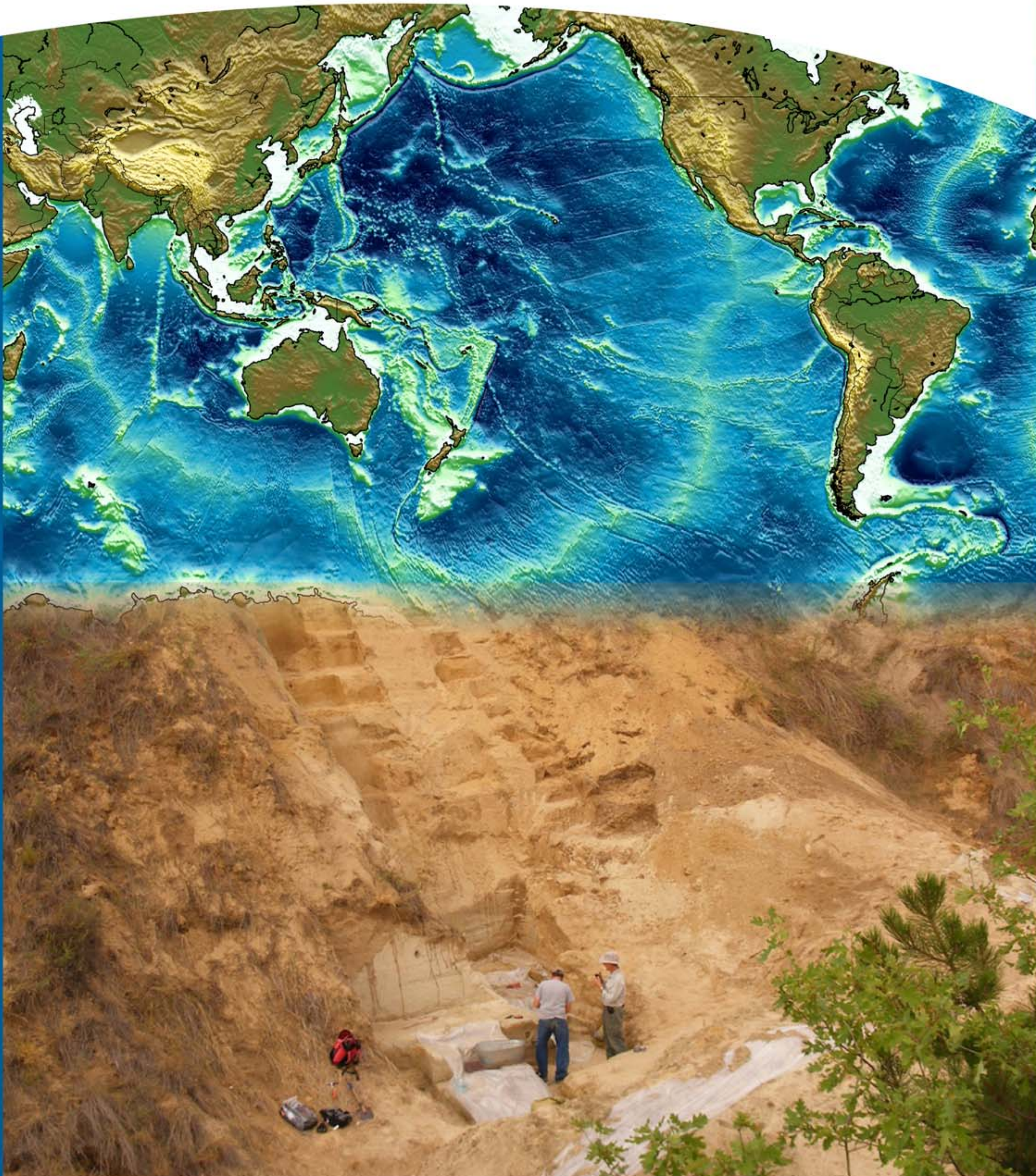

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Case Study

GROUNDWATER DEGRADATION AND ITS HEALTH EFFECTS DUE TO MINOR ELEMENT CONCENTRATION: A CASE STUDY OF SINGRAULI INDUSTRIAL AREA, MADHAYA PRADESH

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Present study was carried out in industrial sector which is considered as the power house of India. pH, TDS, hardness, copper, iron, cobalt, manganese, zinc and chromium were analyzed for 17ground water samples in the selected tube wells which are used for drinking and other domestic purpose. Preliminary field survey was carried out to understand the overall impact of industrialization on the groundwater resources of Singrauli area Physico-chemical parameters pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in the field by using portable multi parameter analysis kit. The minor ions were analyzed in the laboratory. The results obtained are compared with WHO and ICMR standards for drinking water quality. The physico chemical analysis shows alkaline nature of water, soft to moderately soft; TDS and total alkalinity exceeds the desirable limit. The minor ions concentration like Cu^{++}, Mg and Zn^{++} are within the permissible limit prescribed by world health organization, 2011 whereas Ni, Fe^{++}, Co, and Cr show higher concentrations which are the main constituents responsible for degrading the quality of groundwater and has many adverse health effects on the human population.

Keywords: Groundwater Degradation, Industrialization, Drinking water, Trace elements, Health effects

INTRODUCTION

Although water is available on earth in plenty but less than 1% of it is available for human consumption which is being overexploited and polluted due to anthropogenic activities involving huge disposal of pollutants into water bodies which make it unfit for sustenance of life (Ramachandra and Solanki, 2007). Quality of water is just as important as its quantity, safe drinking water is the primary need of every human being but increasing population and its necessities have lead to the deterioration of surface and sub surface water (Todd, 2004; Gupta et al., 2009). Groundwater on the other side is important source of water for drinking, agriculture and industrial purposes due to the

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rapid increase in population, rapid industrialization and unplanned urbanization, excessive use of fertilizers and pesticides, have a major role in deterioration of quality of groundwater (Joarder et al., 2008; Saravankumar and Kumar, 2011). Anthropogenic activities have accelerated the release of metals present naturally in the earth's crust at various levels into the ecosystem which causes serious environmental problems posing threat to human beings (Angelone and Bini, 1992; Lantzy and Mackenzie, 1979; Ross, 1994). Metals and metal chelates are present in industrial wastes create water pollution which results in deterioration of water quality and making it unfit for human consumption and sustaining aquatic life (Amman et al., 2002; Das et al 1997; Ghosh and Vass., 1997). Many of today's health problems are the result of long-term exposure to heavy metals as environmental contamination. The role played by the trace element in the human and animal metabolism was assessed based on the results of studying these elements. The total concentration of heavy metals in the drinking water - the desired and permissible level - helped in understanding the cause and remedial measures of various chronic ailments (Taqveem and Abbasi, 2004).

Essential trace elements like Cu^{++}, Ni, Fe^{++}, Co, Mn, Zn^{++} and Cr concentrations in groundwater samples show a considerable variation are responsible for changes which have adverse impact on soil fertility and ultimately on quality of water (Sonwane et al., 2009) and their deficiency or excess may lead to several disorders in the human body. In the entire study area the rapid development of surface mining, industrialization, change in land use/land cover, population growth and other human activities have led to deterioration of groundwater resources. It is essential to monitor such type of pollution in the industrial area by measuring the concentration some minor ions to check the water borne diseases which may spread to entire population in the area.

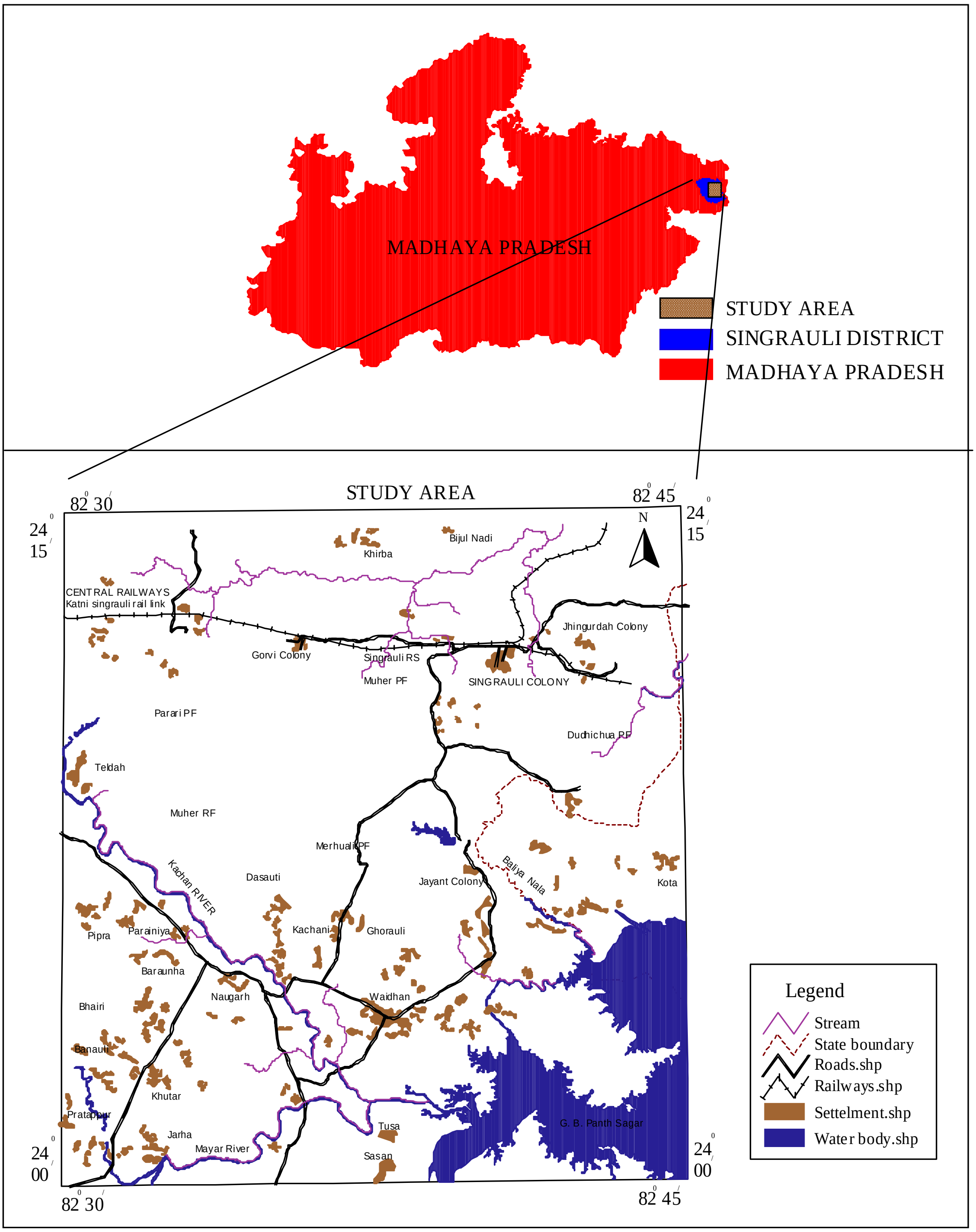
MATERIALS AND METHODS

The study area situated within the geo-coordinates 24^0 00' to 24^0 15' N latitudes and 82^0 30' to 82^0 45' E longitudes, and partly in Singrauli district of Madhya Pradesh and partly in Sonebhadra district of Uttar Pradesh (Figure 1). The seventeen (17) groundwater samples which were collected from different locations around Singrauli mining area for analysis of physical parameters and minor elements concentration were used for both domestic and agricultural purpose. Base Map traced from SOI toposheet were updated from IRS LISS FCC of 4th May 2010 was utlised for groundwater sample location for sampling around the industrial area (Figure 2). The samples from tube wells were collected after 5-10 minutes of pumping and collected in sterilized screw capped polythene bottles of one litre with necessary precautions. Immediately after the sampling the pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in the field by using multi parameter analysis kit (INOVA-WTFK). Trace metals like Cu^{++}, Ni, Fe^{++}, Co^{++}, Mn^{++}, Zn^{++}, Cr were determined by Atomic Absorption spectrum (Perkin Elmer AAnalyst 800) using multi element Perkin-Elmer standard solution. The analysis of the sample was done on the basis of standard methods suggested by the American Public Health Association (APHA, 1995).

RESULTS AND DISCUSSION

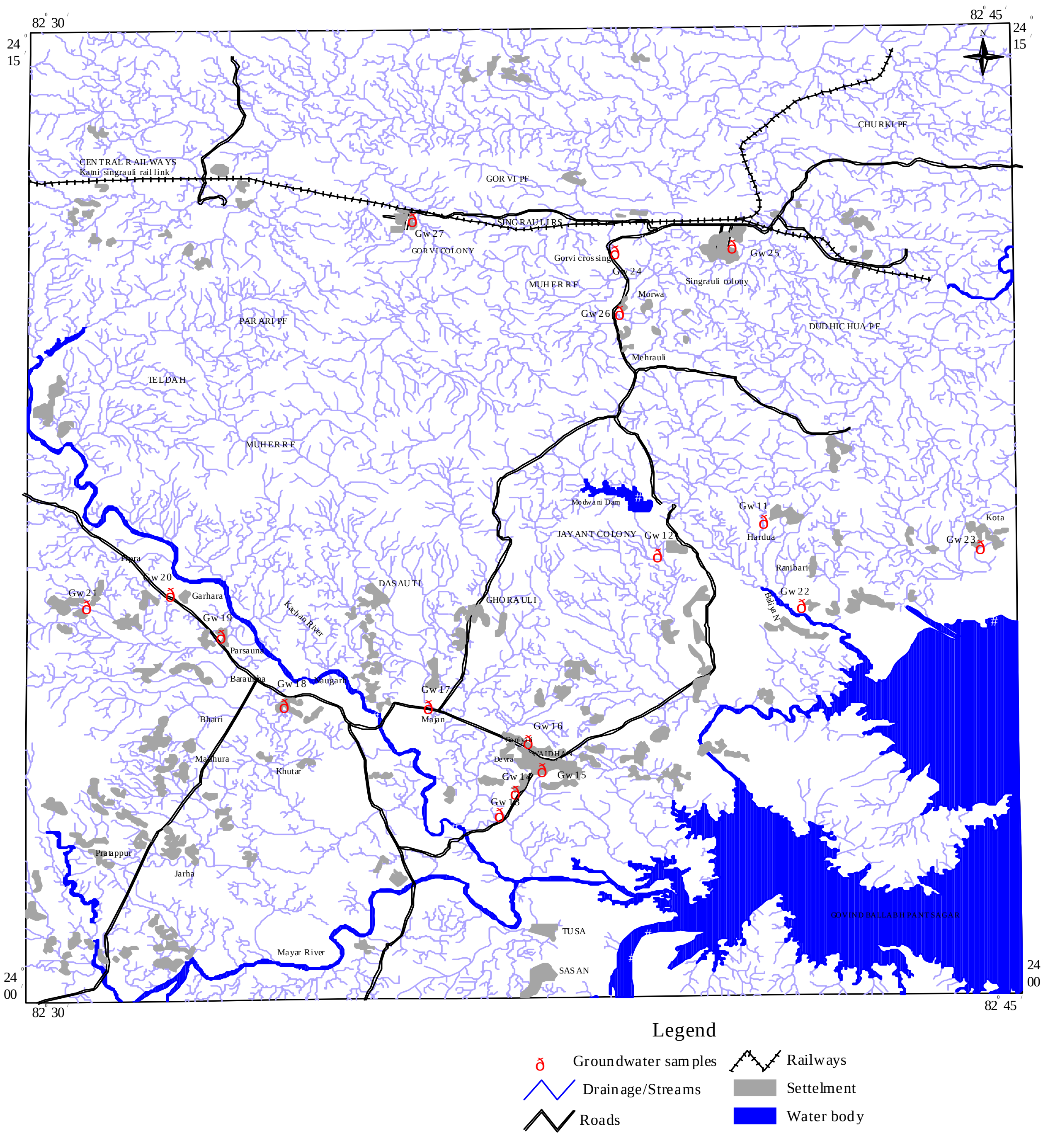
The results of analysis for physical parameters and trace elements are given in the Table 1. Water

Figure 1: Map Showing Study Area in Singrauli District



is colorless, odorless, and free from turbidity whereas, at Ganyari and Marrak slightly brackish taste with turbidity has been observed. The temperature of collected groundwater samples

Figure 2: Ground Water Sampling Point Location Around the Industrial Area



ranges below 20ºC so it is fit for public use (Zajic, 1971). The pH value ranges from 7.8 to 8.7 with an average of 8.3 which indicate the alkaline nature of water. The limit of pH value for drinking water is specified as 6.5 to 8.5 (ISI, 1983) and is not harm full when is within limits of 11 to 6.5 (WHO, 2011). Total dissolved solids (TDS) ranges from 176 mg/l to 1845 mg/l with an average of

1029.0 mg/l. Classification (After Fetter, 2000) suggests value less then desirable limit are under fresh water category are Gw 19, 20, 21, 22, 23, 24, 25 and 26 whereas the Gw 11, 12, 13, 14, 15,16,17,18 and 27 fall under brackish water category (Table 2). Runoff from mine dumps, industries, residential area and atmospheric dust fall which eventually get added into the water bodies, whereby mineral ions migrates down the water table increasing the TDS in groundwater (Shyamala et al,. 2008). Hardness value ranges from 48 – 148 mg/l with average of 102.6 mg/l which indicates the water is soft to moderately hard (Sawyer and McCarty., 1967; Saravankumar and Kumar, 2011) Table 3. Five samples Gw 11, 22, 24, 25 and 26 show soft water whereas sample Gw 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23 and 27 indicates moderate hardness. Electrical conductivity (Ec) value from 69.6 µmho/cm to 869 ìmho/cm with an average of 348.2 µmho/cm which shows value ranges from low class (> 500 µmho/cm) to medium conductivity 500 µmho/cm

Table 1: Physical and Trace Elements Concentration of Groundwater Samples in mg/l

Sample. No	Location	pH	TDS mg/l	Conductivity µmho/cm	Hardness mg/l	Cu^{++} mg/l	Ni mg/l	Fe^{++} mg/l	Co^{++} mg/l	Mn mg/l	Zn^{++} mg/l	Cr mg/l
Gw 11	Dudichua crossing	8.7	1347	437.9	60	0.003	0.016	0.030	0.008	0.002	0.014	0.235
Gw 12	Jayant crossing	8.25	1614	487.6	104	0.007	0.030	0.040	0.015	0.222	0.209	0.220
Gw 13	Devra along tussa/sasan	8.16	1022	308.8	112	0.006	0.025	0.074	0.008	0.004	0.021	0.223
Gw 14	Ganyari along tussa/sasan	8.47	1240	404	124	0.006	0.023	0.000	0.013	0.002	0.032	0.236
Gw 15	Waidhan southern side	8.03	1613	519.6	96	0.011	0.029	0.191	0.014	0.014	0.284	0.266
Gw 16	Waidhan northern side	8.1	1272	388.9	112	0.009	0.023	0.034	0.011	0.011	0.023	0.016
Gw 17	Majan chowk	8.31	1143	869.5	136	0.007	0.019	1.451	0.015	0.052	0.256	0.022
Gw 18	Naugarh along waidhan/ Pipra road	8.1	1364	401.2	148	0.026	0.019	0.238	0.009	0.017	0.370	0.009
Gw 19	Parsauna	8.25	853	249.2	124	0.007	0.012	0.534	0.009	0.018	0.169	0.010
Gw 20	Garhara	8.5	907	257.8	140	0.008	0.018	0.030	0.010	0.008	0.735	0.010
Gw 21	Pipra	8.54	937	271.2	120	0.008	0.020	0.063	0.014	0.012	0.091	0.012
Gw 22	Ranibari along Baliya nalla	8.2	447	160.4	52	0.034	0.009	0.309	0.004	0.009	0.086	0.004
Gw 23	Marrak near ash pond	8.6	674	215.2	120	0.068	0.020	0.064	0.011	0.046	0.193	0.009
Gw 24	Gorvi crossing along Jayant	7.9	176	69.6	48	0.007	0.019	0.636	0.006	0.022	0.797	0.011
Gw 25	Singrauli market	7.83	512	155.2	72	0.020	0.012	0.042	0.005	0.015	0.479	0.010
Gw 26	Mehrauli	8.45	527	186.4	52	0.008	0.013	0.203	0.009	0.011	0.118	0.009
Gw 27	Gorvi colony	8.02	1845	536.2	124	0.009	0.022	0.081	0.011	0.026	0.779	0.011
Desirable Limit		6.5	500	400µmho /cm	100	100	0.020 mg/l	0.1 mg/l		0.05 mg/l	5 mg/l	0.05 mg/l
Permissible Limit		8.5	2000		500	500		1mg/l		0.5 mg/l	15mg/l	0.01 mg/l

Table 2: Classification of water based on TDS (After Fetter, 2000)

Category	TDS (mg/l)	Samples No.
Fresh water	0- 1,000	19, 20, 21, 22, 23, 24, 25, 26 (47.05%)
Brackish water	1,000- 10,000	11, 12, 13, 14, 15, 16, 17, 18, 27 (52.9 %)
Saline water	10,000- 100,000	0
Brine water	> 100,000	0

Table 3: Hardness Classification of Water (After Sawyer and McCarty 1967)

Hardness, mg/l as $CaCo_3$	Water Class	Total Sample
0-75	Soft	4
75 - 150	Moderately Hard	13
150 - 300	Hard	0
Over 300	Very hard	0

Table 4: Classification on the basis of EC (After Sarma and Narayanaswamy, 1981)

Class	EC (μS/cm at 25o C)	Sample No
Low Conductivity	< 500	11,12,13,14,16,18,19,20,21,22,23,24,25,26,27 (88.23%)
Medium Conductivity Class I	500- 1000	15, 17, (11.76%)
Medium Conductivity Class II	1000- 3000	0
High Conductivity Class III	> 3000	0

- 1000 ìmho/cm (class I) (Sarma and Narayanaswamy, 1981). The higher Ec values are mostly observed near the mining areas, settlement and industrial areas due to the excessive interaction of chemical and higher TDS values.

The minor elements like Cu^{++}, Ni, Fe^{++}, Co, Mn, Zn^{++} and Cr were analyzed and indicate considerable variation in the concentration. Copper ions estimated to vary from 0.003mg/l at to 0.068mg/l with an average of 0.014mg/l which indicates copper values are within the desirable limits of 0.5mg/l (W.H.O, 2011). From the analytical results, it can be inferred that the groundwater is copper deficient. The deficiency of copper in human body could indirectly increase the risk of skin cancer, anemia, renal disorder, leukemia and certain type of tumors, invasive diseases caused by worms are also connected with deficiency of copper in the body (Passmore et al., 1974; Vohra and Dobrowolski, 1990). Nickel ranges from 0.009 mg/l to 0.030 mg/l with an average of 0.019 mg/l, higher values are observed near industrial waste deposit sites like ash pond, water body where all the water from coal washery are stored act as main source of nickel. In small quantities it is essential, but uptake of too large quantities may cause chances of lung cancer, nose cancer, prostate cancer, respiratory failure, birth defects and heart disorder (W.H.O, 2006).

Iron concentration in groundwater samples ranges from 0.03 mg/l to 1.451 mg/l with an average of 0.236 mg/l which depicts values is higher than the desirable limit (W.H.O, 2011). The higher values of iron in groundwater have adverse effects like, this may damage pancreas, liver, spleen and heart which are called haermosiderosis (Bhaskar et al., 2010; Rajappa et al., 2010). It is an essential component of hemoglobin and myoglobin. Besides, it is necessary for the activity of cytochromes, peroxides, catalase, and certain other hemoprotien and flavoprotien enzymes (Karlson, 1987; Passmore et al., 1974). whereas deficiency of iron causes disease called anemia, causing tiredness, headaches and loss of concentration, immune system is also affected, certain types of tumors and multiplied sensitivity of animals to some carcinogens, and in young children negatively effects mental development (Schrauzer, 1978). Cobalt content varies between 0.004 mg/l to 0.015 mg/l with an average of 0.010 mg/l which indicate the concentration exceeds normal range which shows deteriorated quality of groundwater. Anthropogenic emissions, largely the burning of fossil fuels, account for 55% of all cobalt in the air (Nagpal, 1981). When plants grow on contaminated soil near mining and other industrial area they will accumulate very small particles of cobalt in their parts which we eat and can cause health effects like vomiting, vision problem heart problem and thyroid damage. Cobalt dust may cause asthma like diseases symptoms ranging from cough, shortness of breath and permanent disability and death (http://www.lenntech.com/periodic/elements/co.htm). Magnesium concentration ranges from 0.002 mg/l to 0.002 mg/l with an average of 0.029 mg/l which depicts magnesium is within the desirable limit 0.05 mg/l (W.H.O, 2011). Manganese contributes to the normal development of connective tissue, besides being necessary for respiratory enzymes. It is present in high concentration in mitochondria fraction of human kidney, liver, and pancreas. Humans enhance manganese concentration in the air by industrial activities and through burning fossil fuels. Manganese deficiency can cause health effects like fatness, blood clotting, skin problem, lowered cholesterol levels, birth defects, change in hair colour and neurological symptoms. Manganese deficiency in animals also resulted in retarded growth, motor in coordinator and reduced fertility (Underwood, 1977). Zinc is found in all food and potable water as salts or an organic complex. Zinc concentration ranges from 0.014 mg/l to 0.05 mg/l 0.797 mg/l with an average of 0.274 mg/l which is within the desirable limit which indicates that water is free from zinc contamination. Lack of zinc has been implicated in impaired DNA, RNA and protein synthesis during brain development. For this reason, zinc deficiency during pregnancy and lactation has shown relation with many congenital abnormalities of the nervous system of the offspring's. Further more in children's in sufficient level of zinc has been associated with lowered learning abilities, apathy, lethargy, and mental retardation (Hameed and Vohra, 1990). Chromium concentration varies between 0.004 mg/l to 0.266 mg/l with an average of 0.077 mg/l show higher concentration in the area. Chromium ingestion over admissible limits leads to allergic phenomena and lung cancer and in excess amounts can be toxic especially in the hexavalent form. Sub chronic and chronic exposure to chromic acid can cause dermatitis and ulceration of the skin (Hanaa et al., 2000; Pandey et al., 2010; Puri et al., 2011).

CONCLUSION

The present study carried out at different location around industrial area reveled that groundwater is alkaline, soft to moderately hard and falls in fresh to brackish category. The minor ions concentration like Cu^{++}, Mg and Zn^{++} are within the permissible limit prescribed by world health organization, 2011 whereas Ni, Fe^{++}, Co, and Cr show higher concentrations which are the main constituents responsible for degrading the quality of groundwater. Higher concentration of minor ions in the groundwater is mostly due to the industrial and anthropogenic activity like, nickel alloys were used in aluminum industries, burning of coal in thermal power plants which release nickel into air by settling down to the ground after reaction with rain drops may also increase the concentration. Weathering processes in rocks release iron into the water as iron carbonate. However municipal and industrial waste effluents are primary sources of cobalt in the environment. Anthropogenic emissions, largely the burning of fossil fuels, account for 55% of cobalt in the air (Nagpal, 1981). The constant use of groundwater for drinking purpose around the industrial sector make the peoples prone to many severe diseases like, cancer, respiratory failure, birth defects, damage liver, asthma, shortness of breath, permanent disability and death. So the groundwater near the industrial vicinity is not fit for drinking. The industrial sector should have to provide drinking water facilities to the local population so that their health will not be affected and waste water effluents will be released after proper treatment into the disposal sites for that municipal corporation should take appropriate steps to check the water pollution.

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