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Assessment of groundwater quality with reference to its portability in near vicinity of lignite mine at Matano Madh, Kachchh, Gujarat, India

Mrugesh H. Trivedi[1*], Jyotindra J. Bhatt[2] and Deepak Tirky[1]

[1]Department of Earth and Environmental Science, KSKV Kachchh University, Bhuj, Gujarat, India
[2]Department of Chemistry, KSKV Kachchh University, Bhuj, Gujarat, India

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ABSTRACT

Coal is one of the most influencing factors on Gross Domestic Product (GDP) of any developing and developed country. Lignite source in Gujarat is one of the strongest reasons for the industrial development. Lignite has been found ever since Laki shales of Eocene age in the Kachchh district. The other side of lignite mine is adverse foot print to ground water contamination by its leachate. Ground water resources play pivotal role for people who leaves in arid region like Kachchh and they always strives on their foot to get drinking water. Thus, the present analysis was undertaken with an objective to determine the ground water quality appraisal. Parameters like temperature, pH, TDS, EC, Alkalinity, Total hardness, Calcium and Magnesium dependent hardness, COD, BOD, DO, Nitrate, Fluoride, lead and copper have studied. Analysis was performed using standard methods of American Public Health Association (APHA, 1998) for water quality appraisal. Total seventy ground water samples from six villages within approximately 10 km radium of mining area have been collected for the study. The result revealed average temperature of GW was 24.18ºC; pH was 6.4 which is slightly acidic and might be due to leachate from mining. Average Fluoride concentration was 2.4 ppm which may cause bone related problem if water use for drinking purpose. Average lead concentration in ground water is around 0.07 ppm which is little higher than the standard value. Moreover, significant alternation was also found in parameters like COD, DO, Alkalinity and hardness. Outcome of the results strongly recommend water treatment before use for portable purpose.

Key words: Ground water, Heavy metal contamination, Lignite mine, physic-chemical parameters, semi arid region

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INTRODUCTION

About 97.2% of water on earth is salty and only 2.8% is present as fresh water from which about 20% constitutes ground water. Ground water is highly valued because of certain properties not possessed by surface water[1]. Both anthropogenic pressures and natural processes account for degradation in surface water and groundwater quality[2].

The occurrence of lignite in Gujarat has opened new avenue for industrial development. The occurrence of Lignite is known from the Laki shales of Eocene age in the Kutch district. Presently GMDC has restricted the production of lignite from panadhro (Lignite mining region) for the sustainable utility of lignite reserve and thus it is used only to satisfy the need of GMDC thermal power plant of that area. Therefore, to withstand against the demand of lignite for different purpose in different industries, Lignite mine at mata-no madh region, Kachchh has commenced during the year of 1999-2000. Total geological reserved of mine is estimated 48.92 million tonnes out of which 33.90 million tonnes are minerable reserved. Total lease area for ongoing mining activity is around 1752-61-56 Hectare and total exploration area is 6.48 km^2. Production of lignite had been increased from 119540.180 to 122192.02 tonnes[3,] i.e. from August 2011 to August 2013 respectively (Fig 1 and Fig 2). Kachchh region of Gujarat state is classified as semi-arid region due to very less and scanty rainfall. Therefore, majority of the population residing in kachchh depends on ground water for domestic and agricultural purposes. In recent times, Gujarat has been found with a very high rate of groundwater depletion. In the past two decades, it had lost about 27 percent of its groundwater resources, which indicates a serious "water stress" situation[4]. In the semi-arid region of Kachchh, where the availability of fresh water by precipitation is rare, and geomorphological expression groundwater is high in dissolved minerals, few studies from our laboratory have reported high amount of fluoride contamination in groundwater and its impact on IQ of school children[5,6].

A study conducted by Singh et al (2011)[7] on assessment of groundwater resources of Panandhro Lignite mining region, Gujarat State, India revealed water table in the sand aquifer, due to continuous withdrawal has gone far below the mine bottom and therefore increase chances of contamination from leachate and surface runoff during monsoon. Long and sustained industrial activity in any given area can often lead to soil and ground water contamination. Improper waste disposal practices might contaminate the soils and gradually the entire ground water in the area, impairing ground water quality for many applications including drinking. A similar study undertaken in University of Cape Coast, Ghana, West Africa revealed heavy metal pollution of ground water and surface water due to ongoing gold mining activity [8, 9].

Thus, the study of underground contamination will be of immense help to researchers and environmental regulators working in the area to understand and evolve by initiating remedial measures[10]. Therefore, the present investigation was undertaken with an aims to determine the ground water quality appraisal to check its suitability for domestic and agriculture purpose.

MATERIALS AND METHODS

This research was conducted within 10 km radius of lignite mine of Mata no-madh in the Kachchh district of Gujarat measuring 387 mm with a mean annual rain for 1932–2010 rainfall which is often irregular and erratic. As a consequence, the quality and availability of drinking water has a great influence on the health and psychology of the residents. The present study was therefore undertaken to assess the physico-chemical parameters of the groundwater (GW) to assess its suitability for the purpose of drinking and agriculture. GW samples from bore and dug wells were collected from six villages, namely, Laxmipar, Sisra, Ravapar, Matana-Madh, Dayapar and Gaduli from Lakpat and Abdasa Taluka of Kachchh district. The locations were selected to cover major parts of the taluka and represent overall groundwater quality within 10 km radius of mining activity. Seventy GW samples of bore and/or dug wells of average depth of 560 feet in the area were collected using precleaned plastic sample containers during post monsoon i.e. September to December 2012, when there was a maximum chance for leachate and contamination of groundwater in surrounding area. Water samples were collected in triplicate, labelled and placed in ice box than transferred to laboratory and were preserved by maintaining at 4ºC for further analysis.

For physico-chemical analysis, temperature (ºC), pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), Calcium (Ca), Magnesium (Mg), Chloride (Cl), chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (DO), Nitrate (NO^{-3}), Sulphate (SO_4^{-2}), Fluoride (F), Cadmium (Cd), Copper (Cu), Lead (Pb) and Cobalt (Co) were determined according to the methods prescribed in 1998 by the American Public Health Association (APHA)[11]. F in the GW was measured by ion exchange chromatography and heavy metals were estimated by atomic absorption spectroscopy of Perkin Elmer AAnalyst 200.

Statistical analysis: Data were expressed as Mean ± S.E.M., correlation was calculated between parameters by data analysis from Excell, MS Office 2013.

RESULTS AND DISCUSSION

Fig. 1 and Fig. 2 revealed that from May 2006 to May 2013 there is a significant increase in total area of exploration for mining activity. Table 1 shows that average pH of ground water around Mata-no madh lignite mine is 6.5 i.e. slightly acidic in nature with lowest value of pH in Gaduli i.e. 5.53 to highest pH in Mata-no madh i.e. 7.08.

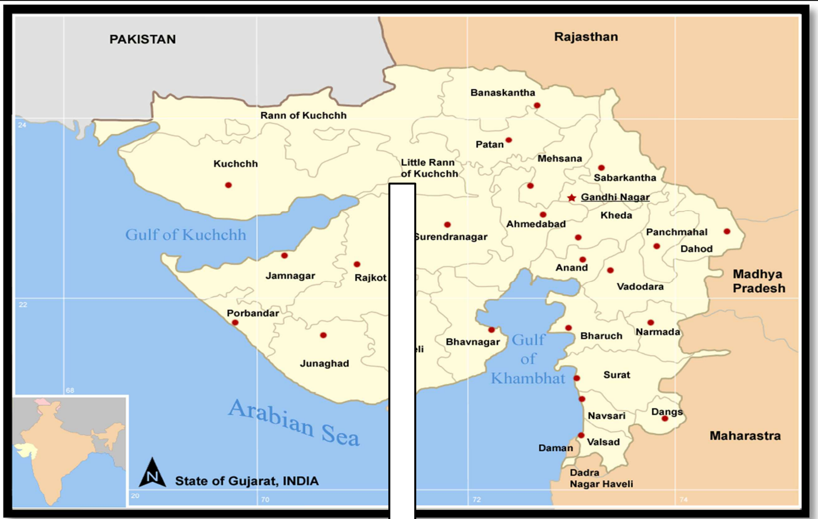

Fig. 1: Area for mining exploration during May 2006

Fig. 2: Area for mining exploration during May 2013

Table : 1 Physico-chemical parameters of ground water in 10 km radium of Mata-no Madh lignite mine, Kachchh, Gujarat (Mean ± S.E.M)

Parameters	DL	PL	Laxmipar	Sisra	Ravapar	MatanaMadh	Dayapar	Gaduli
pH	6.5 – 8.5	NR	6.46 ± 0.04	6.47 ± 0.02	6.34 ± 0.02	7.08 ± 0.04	6.82 ±	5.53 ± 0.03
EC	--	--	3.44 ± 0.55	2.37 ± 0.38	2.20 ± 0.25	2.90 ± 0.25	4.53 ± 0.94	3.33 ± 0.57
TDS	500	2000	4220.00 ± 26.07	5333.33 ± 10.01	3543.33 ± 15.21	5000.00 ± 10.01	9110.00 ± 52.45	7110.00 ± 12.03
Chloride	250	1000	372.00 ± 2.94	415.80 ± 3.55	429.30 ± 4.32	702.00 ± 2.02	742.60 ± 5.89	781.20 ± 3.51
Calcium	75	200	742.00 ± 0.52	693.00 ± 0.12	427.00 ± 0.29	518.00 ± 2.4	1232.00 ± 0.47	539.00 ± 0.29
Mg	30	100	241.89 ± 1.31	110.69 ± 1.34	104.03 ± 0.92	120.86 ± 2.80	216.67 ± 3.22	154.78 ± 0.07
TH	300	600	1733.33 ± 18.24	1146.67 ± 2.4	853.33 ± 1.07	1013.33 ± 3.5	2120.00 ± 0.2	1173.33 ± 0.17
TA	200	600	733.40 ± 2.07	612.00 ± 2.00	748.00 ± 4.23	732.50 ± 3.18	714.00 ± 2.24	501.70 ± 3.48
COD	Absent	--	74.67 ± 1.44	50.67 ± 0.85	82.67 ± 0.41	74.67 ± 1.24	64.00 ± 0.31	34.67 ± 0.63
Nitrate	45	--	32.00 ± 0.98	35.00 ± 1.02	47.00 ± 1.63	40.00 ± 1.22	48.00 ± 2.30	39.00 ± 1.03
Fluoride	1.5	--	1.52 ± 0.02	1.20 ± 0.08	1.70 ± 0.02	1.90 ± 0.07	3.40 ± 0.91	1.80 ± 0.05
Sulphate	150	400	9.37 ± 1.04	9.91 ± 1.03	9.18 ± 0.92	9.69 ± 0.55	8.63 ± 0.67	9.66 ± 0.45
Cadmium	0.01	--	0.32 ± 0.01	BDL	0.28 ± 0.01	0.34 ± 0.01	0.11 ± 0.01	BDL
Cobalt	0.07	--	0.16 ± 0.00	0.01 ± 0.00	0.11 ± 0.01	0.18 ± 0.01	0.10 ± 0.00	0.16 ± 0.00
Copper	0.05	1.50	1.34 ± 0.02	1.10 ± 0.01	1.61 ± 0.00	1.77 ± 0.05	0.95 ± 0.03	1.62 ± 0.01
Lead	0.10	--	0.01 ± 0.00	0.06 ± 0.00	0.11 ± 0.00	0.05 ± 0.00	0.09 ± 0.001	BDL
DO	<6	--	4.00 ± 0.03	4.50 ± 0.02	3.50 ± 0.01	4.00 ± 0.08	4.00 ± 0.03	3.50 ± 0.08
BOD	6.00	--	7.20 ± 1.02	7.00 ± 0.93	7.00 ± 0.52	5.40 ± 1.03	6.50 ± 0.90	6.00 ± 1.04

DL: Desirable Limit; PL: Permissible Limit

Table 2: Correlation analysis of studied parameters

Parameters	***pH***	***EC***	***TDS***	***Cl***	***Ca***	***Mg***	***TH***	***TA***	***COD***	***NO_3***	***F***	***SO_4***	***Cd***	***Co***	***Cu***	***Pb***	***DO***	***BOD***
pH	1.00																	
EC	0.12	1.00																
TDS	-0.05	0.81	1.00															
Cl	-0.07	0.56	0.75	1.00														
Ca	0.34	0.84	0.76	0.24	1.00													
Mg	0.05	0.82	0.39	0.05	0.68	1.00												
TH	0.23	0.90	0.64	0.17	0.93	0.90	1.00											
TA	0.78	0.01	-0.37	-0.38	0.15	0.16	0.17	1.00										
COD	0.66	-0.16	-0.54	-0.44	-0.07	0.04	-0.02	0.97	1.00									
NO_3	0.17	0.22	0.37	0.43	0.24	-0.18	0.05	0.27	0.25	1.00								
F	0.32	0.83	0.79	0.63	0.78	0.45	0.69	0.22	0.07	0.71	1.00							
SO_4	-0.25	-0.66	-0.45	-0.19	-0.68	-0.53	-0.67	-0.48	-0.38	-0.70	-0.84	1.00						
Cd	0.55	-0.12	-0.59	-0.29	-0.25	0.12	-0.09	0.84	0.90	0.02	-0.06	-0.18	1.00					
Co	-0.08	0.25	-0.11	0.37	-0.28	0.31	-0.02	0.12	0.20	-0.06	0.08	-0.06	0.57	1.00				
Cu	-0.19	-0.48	-0.52	0.15	-0.85	-0.45	-0.73	-0.02	0.16	-0.04	-0.41	0.42	0.46	0.69	1.00			
Pb	0.47	-0.16	-0.02	-0.14	0.18	-0.36	-0.07	0.55	0.52	0.77	0.37	-0.51	0.14	-0.48	-0.24	1.00		
DO	0.53	-0.01	0.05	-0.31	0.38	0.05	0.25	0.10	-0.05	-0.45	-0.13	0.28	-0.18	-0.60	-0.60	0.02	1.00	
BOD	-0.15	-0.16	-0.31	-0.82	0.17	0.25	0.22	0.20	0.21	-0.18	-0.25	-0.20	-0.05	-0.51	-0.53	0.21	0.20	1.00

Average value of conductivity is 3.13 mmhos/cm which might be due to high amount of TDS, highest value of conductivity was found in Dayapar i.e. 4.53 mmhos/cm where TDS amount was also very high i.e. 9110 gm/l and lowest amount of conductivity was found in Ravapar i.e. 2.20 mmhos/cm where TDS value was also the lowest among the studied villages i.e. 3543.33 mg/l (Table1). Concentration of TDS was of great concern in studied area as it is highly significant as compare to permissible limit[12]. Results are in accordance with earlier study conducted by Tiwary and Dhar (1994) and Chandra and Jain (2013)[13, 14].

Table 1 shows that Maximum concentration of chloride i.e. 781.00 mg/l was found in Gaduli and the lowest amount was found in 372.00 mg/l at Laxmipar with an average value of 573.82 mg/ml which was within the permissible limit. Lowest calcium concentration was 427.00 mg/ml in Ravapar and highest concentration was 1232.00 mg/ml in Dayapar with an average value of 691.8 which was significantly higher than permissible limit. Average concentration of Mg was 158.10 mg/l, value range from 104.03 to 241.89 mg/l was significantly higher than permissible limit. Average value of total hardness as $CaCO_3$ was 1340 mg/l which was highly significant as compared to permissible limit. Maximum concentration of TH was found at Dayapar i.e. 2120.00 mg/l and lowest was 853.33 mg/l in Ravapar. Average total alkalinity value was slightly higher than permissible value i.e. 673.30, the value range from lowest i.e. 501.7 mg/ml in Gaduli to highest i.e. 733.40 mg/l in Laxmipar. Average nitrate concentration in studied samples were within permissible limit i.e. 40.17 mg/l, values range from highest in Dayapar i.e. 48.00 mg/l which is slightly higher than permissible limit to lowest in Laxmipar i.e. 32.00 mg/l.

Average fluoride concentration in studied samples were slightly higher than the permissible limit i.e. 1.92 mg/l, values range from 3.40 mg/l in Dayapar which is highly significant than permissible limit to 1.20 mg/l in Sisra within permissible limit. Concentration of sulphate was below desirable limit and value range from 8.63 mg/l to 9.91 mg/l in Sisra and Dayapar. Average value of cadmium was higher than permissible limit i.e. 0.18 mg/l, value range from highest 0.34 mg/l in Mata-no Madh to lowest below detectable limit in Sisra and Gaduli. Average concentration of cobalt was higher than permissible limit i.e. 0.12 mg/l with value range from highest in Mata-no Madh i.e. 0.18 mg/l to 0.01 mg/l in Sisra. Average concentration of copper was well within the prescribe limit i.e. 1.40 mg/l. Average value of lead was within permissible limit i.e. 0.05 mg/l. However, highest amount in Ravapar is 1.1 mg/l which was slightly higher than permissible limit and matter of concern from the point of view of heavy metal contamination of ground water (Table 1). Number of studies revealed about the contamination of ground water due to ongoing mining activities as well as industrial activity.[13-15].

Average value of DO was 3.92 mg/l which was within the desirable limit in all studied villages. Average value of BOD was 6.52 mg/l which was slightly higher than permissible limit and indicates about biological contamination which is in accordance with Dhar B. B. (1993)[16]. Values range from 7.20 mg/l in Laxmipar to 5.40 mg/l in Mata-no Madh. As per prescribe standard ground water should not contain any COD value. However, in present study average value of COD is 63.56 mg/l, value range from 34.67 mg/l in Gaduli to 82.67 mg/l in Ravapar (Table 1).

CONCLUSION

Overall quality of ground water in 10 km radius of lignite mine of mata-no madh is not pristine. Therefore, should not recommend for its direct use for domestic and agricultural purpose. Opencast mining disturbs the aquifers and water table. This causes permanent flow of water into the mine and loss of water from aquifers. Mine water is hard in nature and has high total dissolved solids (TDS) which is not suitable for drinking purpose was described earlier by Dhar, 1993 as environmental implication in Indian coal mining. As presented in Table 2, positive correlation i.e. 0.81 between TDS and EC revealed high potency of ionisation for dissolve compound. Because of high value of total hardness water is not suitable for irrigation purpose. Based on our analysis we suggest for continuous monitoring of ground water quality and water table within 10km radium of Mata-no madh lignite mine and make primary and secondary treatment mandatory before using it.

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