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RESEARCH ARTICLE

STUDY OF GROUND WATER QUALITY IN AN ACTIVE RIVERBED MINING AREA IN MOHAND RAO WATERSHED, HARIDWAR (UTTARAKHAND), INDIA

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ABSTRACT

With the rapid development of mining, problems related to groundwater in mining areas are becoming increasingly prominent. In mining areas a series of environmental problems, such as pollution of groundwater and decline of aquifer levels have occurred. The effects of riverbed mining activity on the quality of ground water within Mohand Rao watershed were studied. The quality was assessed in terms of physicochemical parameters. For the study, different types of collection samples varying in depth were collected from the sites demarcated in the watershed area. The groundwater was analysed for pH, Total Dissolved Solid, Conductivity, Dissolved Oxygen, Hardness, Calcium, Magnesium, Chloride and Alkalinity. The study concluded that the water quality parameters were within the desirable limits as per specified BIS specifications 2012 except Calcium and Magnesium levels. This indicates that due the mining operations the un weathered material is exposed to weathering.

Key words: Water, River bed Mining, Physico-Chemical, Mohand Rao Watershed

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INTRODUCTION

The quality of ground water in some parts of the country is changing as a result of human activities. For decades the quality of water has been an issue of environmental concern. Many unseen dissolved minerals and organic constituents are present in ground water in various concentrations. Most of them are harmless, others are harmful, and a few may be toxic. Day by day increase of an made activities including agricultural and industrial use of ground water, results in the scarcity of ground water. (Sivagurunathan, 2005 and Kesavan and Parameswari, 2005). The groundwater serves the majority of purposes where there are no other sources. The coasts are one such region, which solely depends on groundwater for all its needs. Groundwater quality is affected by both geogenic and anthropogenic agents (Sheikhy *et al.,* 2014). Ground water is a very valuable natural resource for the economic development and secure provision of potable water supply in both urban and rural environments (Foster *et al.,* 2003; Wakode *et al.,* 2011). Nowadays groundwater pollution has become one of the most serious problems throughout the world. Urbanization, industrialization and agricultural activity affecting groundwater quantity and quality (Jat *et al.,* 2009). Ground water protection against contamination by the human activities is one of the most important tasks of environmental awareness on a world wide scale. If the ground water reservoir is left unchecked, the minor contamination can damage the whole reservoir with the passage of time (Kamboj, 2012). Water quality is based on the physical and chemical soluble parameters due to weathering of source rocks and anthropogenic activities. Protecting the ground water is a major environmental concern as the importance of water is very well known. Developing strategies for protection of aquifer contamination is also necessary for proper planning and designing of water resources. (Bajpayee *et al.,* 2001). The safe, portable water is extremely necessary for good health. Ground water is vital and most suitable resource of fresh water for human utilization in both urban as well as rural areas. The ground water is important for existence of human society and this fact cannot be denied. In several states of India, more than 90% populations are dependent on ground water for drinking and other purposes (Ramchandraiah, 2004). With the rapid progress of mining, problems related to groundwater in mining areas are becoming gradually more prominent. For example, due to drainage of groundwater, a series of environmental problems, such as pollution of groundwater and decline of aquifer levels, in mining areas have occurred (Dhakate *et al.,* 2008). In order to achieve sustainable development and reach a secure status regarding both quantity and quality of groundwater bodies, some management methods for environmental protection should be introduced, particularly in forecasting the groundwater changes and the control of contamination before mining activities (Jiménez-Madrid *et al.,* 2012). Illegal mining in various Indian states shows

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encroachment of forest land (Kamboj et al, 2012). The knowledge of hydro-chemistry is important to assess the ground water quality in any area in which the ground water is used for both irrigation and drinking needs (Srinivas *et al.,* 2013). The water quality estimation may give clear information about the subsurface geologic environment in which water is present (Raju *et al.,* 2011). For sustaining all life on the earth, due to multiple benefits of water and the problems created by its excesses, shortage and quality deterioration, water as a resource requires special attention. So the aim of the study is to assess the quality of groundwater and to assess the hydro geochemical parameters for suitability of groundwater resources in the study area (Shanmugasundharam *et al* 2017).Ganga river is also is also assessed for its water quality during Kanwer Mela (Kamboj *et al*,2012). Impacts of riverbed mining activity on the quality of ground water within Mohand Rao watershed were studied. The quality was assessed in terms of physicochemical parameters.

MATERIALS AND METHODS

Study area

Present study was conducted in Mohand Rao watershed, district Haridwar, Uttarakhand. For the study three different types of collection samples differing in depth were selected from the sites demarcated in the watershed area. The description of sampling sites, type of collection samples and their depth has been shown in Table 1.

Collection of samples

The water sample collection and analysis has been done as per the standard methods prescribed in Bureau of Indian Standards (BIS): 10500 (2012). The water samples were collected from bore well, govt. Hand pump, private hand pump which was located at above mentioned three sites in Mohand Rao watershed i. e. Banjarewala (forest area), Banjarewala village, Gokalwala village at Haridwar respectively.

Analysis procedure of ground water sample

The sample was analysed for various parameters . The pH was recorded on site and remaining parameters Total Dissolved Solid, Conductivity, Dissolved Oxygen, Hardness, Calcium, Magnesium, Chloride, Alkalinity, were analysed in laboratory. TDS and conductivity were analysed by conductivity and TDS meter while all the remaining parameters were analysed by titrimetric methods using standard methods (APHA, 2012 and Trivedy and Goel, 1986). The water quality index has been calculated by using the standard of drinking water quality by the World Health Organization (2004), Bureau of Indian Standards (1993), and Indian Council for Medical Research (1975). The weighted arithmetic index method is used for the calculation of water quality index of the lake. The quality rating or sub index (qn) was calculated using the following formula.

$$qn = 100[(Vn - Vio) / (Sn - Vio)]$$

Where

qn = quality rating for the nth water quality parameter.
Vn = estimated value of the nth parameter at a given sampling station.
Sn = standard permissible value of nth parameter
Vio = ideal value of nth parameter in pure water.

Ideal value in most cases $V_{10} = 0$ except in certain parameters like pH and dissolved oxygen. The calculation of quality rating for pH and DO ($V_{10} \neq 0$) is 7.0 and 14.6 mg/l respectively. Unit weight was calculated by a value inversely proportional to the recommended standard values (Sn) of the corresponding parameters

Wn = K/Sn

Where
Wn = unit weight for nth parameter
Sn = standard value for nth parameters
K = proportionality constant.

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly.

W. Q. I. = $\Sigma^{qnWn}/\Sigma^{Wn}$

RESULTS AND DISCUSSION

The various parameters for analysis of groundwater at varying depths were recorded from Banjarewala (forest area), Banjarewala village and Gokalwala village from October to January month of the year 2017. These recordings are given in Table 2. In the present study, the average pH value for bore well sample, govt. Hand pump and private hand pump were found to be 7. 53, 6. 6, and 6. 7 respectively. The most of the pH values are found to be within the permissible limit of WHO (6. 5-8. 5ppm). Kamboj et al, (2016) observed the average pH value of groundwater to be 7. 3 in Roorkee region of Uttarakhand Kamboj and Aswal, (2015) observed the pH value varied from 7.66-7.76 for suitability of Ganga canal water for drinking purpose at Haridwar city. Electrical conductivity is about the conducting capacity of water, which in turn is determined by the presence of dissolved ions and solids. Electrical Conductivity of bore well sample, govt. Hand pump and private hand pump sample were found to be 510. 7 µS/cm, 513. 7 µS/cm, 423 µS/cm respectively. Kumar *et al.* (2016) observed that the Electrical Conductivity values of groundwater quality for drinking and irrigation use in shallow hard rock aquifer of Pudunagaram, Palakkad District, Kerala in post-monsoon are ranging from 107 to 3,000 µs/cm. Average values for Electrical Conductivity recorded by Kamboj et al., (2016) in Roorkee region was 843. 6µS/cm. Average values for Total Dissolved Solids in bore well sample, govt. Hand pump and private hand pump sample, respectively were observed to be 327. 7mg/l, 337. 7 mg/l, 280 mg/l. Sridharan *et al.* (2017) assessed groundwater quality in Puducherry region where TDS varies from 237 to 2320 mg/l. The value for Alkalinity of bore well sample, govt. Hand pump and private hand pump sample was recorded to be 530 mg/l, 500 mg/l., 540 mg/l, respectively. Kumar *et al.,* (2016) observed alkalinity value of 60 mg/L in shallow hard rock aquifer of Pudunagaram, Palakkad District Kerala. Dissolved oxygen is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water, the D. O. value indicate the degree of pollution in water bodies. The present study average value for dissolved oxygen of bore well sample, govt. Hand pump and private hand pump sample were found to be 5. 37 mg/l, 5. 65 mg/l, 5. 73 mg/l. respectively. Rao *et al.,* (2013) observed the value of D. O. 4. 27-5. 16 (mg/l) in Vuyyuru, Part of East Coast of India.

Table 1. Details of collection samples at varying depth in Mohand Rao watershed

S.No.	Type of sample collection	Depth	Location
1	Bore well sample	225ft.	Banjarewala (forest area)
2	Govt. Hand pump	180ft.	Banjarewala village
3	Private hand pump	80ft.	Gokalwala village

Table 2. Analysed data of Groundwater samples at varying depths in three sites of Mohand Rao watershed, Haridwar

.No.	Parameters	Borewell sample	Govt. Handpump	Private handpump	BIS std. (IS10500:2012)
1	pH	07.53±0.15	06.60±0.20	06.67±0.12	6.5-8.5
2	Conductivity (µS/cm)	510.70±0.66	513.67±01.52	423.00±02.00	781-3125
3	TDS (mg/l)	327.70 ±0.75	337.66±01.52	280.00±01.00	500-2000
4	Alkalinity (mg/l)	530.23±0.40	500.67±02.08	440.33±02.52	200-600
5	DO (mg/l)	05.37±0.15	05.65±0.03	05.73±0.06	> 6
6	Hardness (mg/l)	319.67±01.5	361.00±02.00	400.33±01.53	200-600
7	Calcium (mg/l)	264.67±01.53	221.33±01.53	211.00±02.65	75-200
8	Magnesium (mg/l)	55.00±01.00	139.67±02.89	189.33±03.06	30-100
9	Chloride (mg/l)	17.43±0.25	21.27±0.15	11.67±0.25	250-1000

Water Quality Index

Water Quality index (WQI) is defined as a technique of rating which provides the composite influence of individual water quality parameter on the overall quality of water.

Table 3. Status of water quality based on Water Quality Index (W.Q.I)

Water Quality Index	Water Quality Status
00 -25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
< 100	Unsuitable for drinking

Table 4. Standard recommending agencies and unit weight for drinking water

Parameter	Standards	Recommended Agencies	Unit Weight
pH	6.5 – 8.5	ICMR; BIS	0.2188
TDS	500 mg/l	ICMR; BIS	0.0155
Conductivity	1000 µmho/cm	BIS	0.0018
DO	5.0 mg/l	ICMR; BIS	0.3723
BOD	5.0 mg/l	ICMR; BIS	0.3723
Total Hardness	300 mg/l	ICMR; BIS	0.0062
Calcium	75 mg/l	ICMR; BIS	0.025
Magnesium	30 mg/l	ICMR; BIS	0.061

Table 5. Calculation of water quality index of bore well sample

S.No.	Parameters	Observed Value (Vn)	Standard Values (Sn)	Unit Weight (Wn)	Quality (Qn)	WnQn
1	pH	7.5	8.5	0.219	33.33	7.29927
2	Conductivity (µs)	510.7	300	0.371	170.23	63.15533
3	TDS (mg/l)	327.7	500	0.0037	65.54	0.242498
4	DO (mg/l)	5.37	5	0.3723	-37	-13.7751
5	Total hardness (mg/l)	319.7	300	0.0062	106.56	0.660672
6	Calcium (mg/l)	264.7	75	0.025	352.93	8.82325
7	Magnesium (mg/l)	55	30	0.061	183.33	11.18313
				Σ_{Wn}= 1.4416	Σ_{Qn} = 874.92	Σ_{WnQn}= 77.58

Water Quality Index = ΣWnQn/Wn =53.82

Table 6. Calculation of water quality index of govt. hand pump sample

S.No.	Parameters	Observed Value (Vn)	Standard Values (Sn)	Unit Weight (Wn)	Quality (Qn)	WnQn
1	pH	6.6	8.5	0.219	-26.66	-5.83854
2	Conductivity (µs)	513.67	300	0.371	171.22	63.52262
3	TDS (mg/l)	337.66	500	0.0037	67.53	0.249861
4	DO (mg/l)	5.65	5	0.3723	93.23	34.709529
5	Total hardness (mg/l)	361	300	0.0062	120.33	0.746046
6	Calcium (mg/l)	221.33	75	0.025	295.11	7.37775
7	Magnesium (mg/l)	139.67	30	0.061	465.56	28.39916
				Σ_{Wn}= 1.4416	Σ_{Qn} = 1186.32	Σ_{WnQn}= 129.1664

Water Quality Index = ΣWnQn/Wn =89.60

Table 7. Calculation of water quality index of private hand pump sample

S.No.	Parameters	Observed Value (Vn)	Standard Values (Sn)	Unit Weight (Wn)	Quality (Qn)	WnQn
1	pH	6.67	8.5	0.219	-22	56.695
2	Conductivity (µs)	423	300	0.371	141	126900
3	TDS (mg/l)	280	500	0.0037	56	140000
4	DO (mg/l)	5.73	5	0.3723	92.39	28.65
5	Total hardness (mg/l)	400.33	300	0.0062	133.44	120099
6	Calcium (mg/l)	211	75	0.025	281.33	15825
7	Magnesium (mg/l)	189.33	30	0.061	631.1	5679.9
				Σ_{Wn}= 1.4416	Σ_{Qn}= 1313.26	Σ_{WnQn}= 128.4547

Water Quality Index = ΣWnQn/Wn = 89.106

Average values for Total Hardness of bore well sample, govt. Hand pump and private hand pump sample were found to be 319 mg/l, 361 mg/l, 400 mg/l. respectively Khanna *et al.,* (2011)found the total hardness of the ground water across the city Bareilly (U. P.), India ranging between 307- 786. 6 mg/l. Average value for Calcium concentration in bore well sample, govt. Hand pump and private hand pump sample were 264. 67 mg/l, 221 mg/l, 211 mg/l respectively. Kamboj and Choudhary, (2013) observed the value of calcium ranged between 31-151 (mg/l) in ground water samples of the Gazipur Municipal Corporation of Delhi landfill sites. Magnesium is an essential ion for functioning of cells in enzyme activation, but at higher concentration, it is considered as laxative agent, whose deficiency may cause structural and functional changes in human beings. The permissible limit is 30 mg/l as per BIS standards. The concentration of Calcium was found above the permissible limits. This is due to exposure of unweathered material containing Calcium and Magnesium. Value for Magnesium concentration in bore well sample, govt. Hand pump and private hand pump sample were 55 mg/l, 139 mg/l, and 189 mg/l respectively. The concentration of Magnesium in govt. Hand pump water samples and private hand pump samples were found above the permissible limits Shayamala, *et al.,* (2008) observed the value of Magnesium 30-100 (mg/l) in Vuyyuru, Part of East Coast of India. Chloride concentration in bore well sample, govt. Hand pump and private hand pump sample were 17. 43 mg/l, 21. 27 mg/l, and 11. 67 mg/l respectively. The Chloride plays an important role in balancing level of electrolyte in blood plasma, but higher can produce some physical disorder. Rao *et al.,* (2013) observed the value of Chloride 278-347. 94 (mg/l) inVuyyuru, Part of East Coast of India. Choudhary *et al.,* (2014) find the value of chloride 9. 5± 2. 22 in Ri- Bhoi District, Meghalaya

Conclusion

The study carried out in Mohand Rao Watershed, Haridwar on groundwater samples revealed that water quality parameters of pH, Electrical Conductivity, TDS, Alkalinity, DO, Hardness, Chloride were within the permissible limits as per BIS specifications 2012 but Calcium and Magnesium levels were above the permissible limits. This indicates that due the mining operations the unweathered material is exposed to weathering. The WQI for bore well sample at 225 ft. depth indicated poor quality. WQI calculated values for water samples from depth of 180 ft and 80 ft ranged above75 indicating very poor quality of water. This concludes that the water quality of the study area is very poor and not suitable for drinking purpose. There is an urgent need to deal with emerging problems related to groundwater depletion as well as quality deterioration. The present study will be helpful in drawing attention of water sector planning and management department, industrial management planning authorities, municipalities and thus maintain and sustain the ground water quality for drinking.

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