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ORIGINAL ARTICLE

Assessment of Ground water quality and its health impact on residents of Morena City, Madhya Pradesh, India

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ABSTRACT
Ground water quality of small city is degrading by various human activities. So keeping in view the importance of ground water quality and its impact on human health, ten different sampling sites (S_1- S_{10}) were selected for the evaluation of physico-chemical and microbiological parameters. Water samples of different sits were continuously investigated and monitored from May to October-2016. Observed results were compared with (Bureau of Indian Standards 10500: 2012).Correlation matrix of all physico-chemical and microbiological parameters were examined during study. In present study, an attempt was made to assess the existence of pollution in ground water quality and health impact of sampling sites locality of Morena city were observed with help of questionnaire survey.
Keywords*: Ground Water Quality, Questionnaire Survey, Health Impact, Morena City.*

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INTRODUCTION

The quality of water is of vital concern for mankind since it is directly linked with human health, protection of the environment, plant growth and sustainable development [4, 18]. Much of diseases which affects humanity, especially in the developing countries can be traced to lack of safe and wholesome [16]. Increasing population and its necessities have led to the deterioration of surface and sub surface water [15].

Water covers over 71% of the earth's surface and is a very important natural resource for people [11]. Yet, only 2.5% of the earth's water is fresh and thus suitable for consumption. Not only that, but out of 2.5%, more than two-thirds is locked away in glaciers and not particularly able to help meet the growing demands of society [19].Water contamination is one of the major threats to public health of all over world. Water pollution is the deterioration of water quality due to the addition of wastes coming from industries, domestic and agriculture. Utilization of such water for beneficial use causes contrary effects on environment and public health. Industrialization and emergence of urban units placed immense stress on water resources and discharge of wastewater into natural water resources that decreases ground and surface water quality [5]. Drinking water contamination with pathogenic microbes has been the cause of serious diseases in many parts of the world. It has also been regarded as a major cause of waterborne diseases like diarrhea, nausea, gastroenteritis, typhoid, dysentery, and other health problems [8, 10].

The groundwater analysis for physical and chemical properties is very important for Public health studies. These studies are also main part of pollution studies in the environment. The groundwater contains dissolved solids possesses physical characteristics such as odor, taste and temperature. The natural quality of groundwater depends upon the physical environment, the origin, and the movement of water. As the water moves through the hydrological cycle, various chemical, physical and biological processes change its original quality through reactions with soil, rock and organic matter. Natural processes and human activities cause the changes in groundwater quality, directly or indirectly. According to WHO organization, about 80% of all the diseases in human beings are caused by water [13]. In present study, an attempt was made to assess the study the water pollution in ground water quality and its impact on the health impact of residents in Morena city.

MATERIALS AND METHODS

Study Area

Morena city is a town in the Morena district, in the Indian state of Madhya Pradesh. It recently has been governed by a municipal corporation. Morena city is located 26.5°N latitute78.0°E longitude, 39 km away from the research center. It has an average elevation of 177 meters from MSL (580 feet). The Morena City has a widely dispersed population of 288,303 as per the census of 2011. The Morena climate can be termed as extremes, both in summer and winter. The summers are usually very hot and the winters very cold in Morena. The rains in Morena are, however, restricted only to the monsoon months. The north westerns wind blows, predominantly, over the city of Morena.

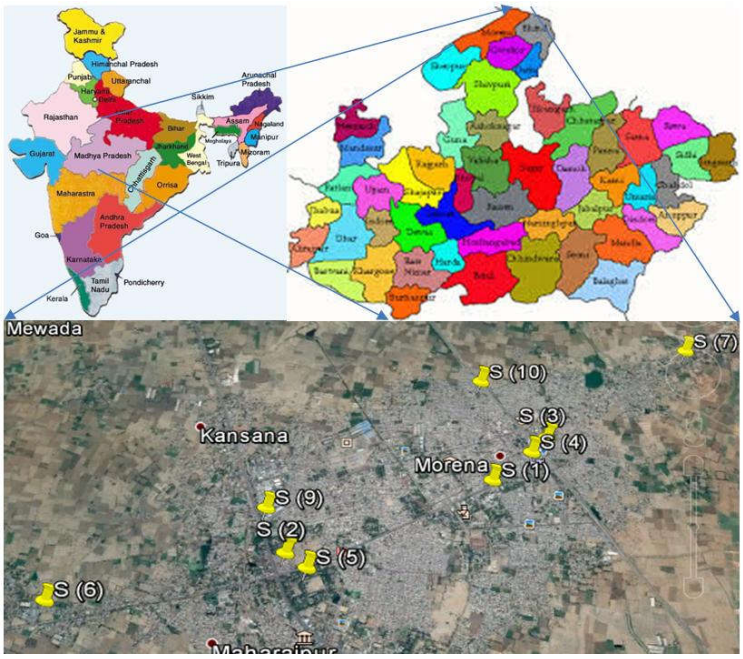

Fig1: Map of Morena City sampling site

Sample Collection

Using stratifies random sampling for physico-chemical analysis 10 sampling sites were selected, depicted as (S1) District hospital campus, (S2) Private bus stand, (S3) Railway Station (high density area), (S4) Hanuman chauraha, (S5) Chambal colony, (S6) Morenagaon, (S7) AmbahPorsaBus Stand Badokhar, (S8) Lalor Village, (S9) K. S. Mill Chouraha (Industrial site), (S10) Singalbasti [Fig 1].

Table.1: Acceptable and permissible limits for drinking water as per IS10500:2012.

S.No.	Parameter	Requirement (Acceptable limit)	Permissible limit
1.	Temperature	-	-
2.	pH value	6.5– 8.5	No relaxation
3.	Electrical conductivity, µS/cm	400	-
4.	Total dissolved solids (TDS), mg/L	500	2000
5.	Total alkalinity as $CaCO_3$, mg/L	200	600
6.	Total hardness as $CaCO_3$, mg/L	200	600
7.	Calcium as Ca, mg/L	75	200
8.	Magnesium as Mg, mg/L	30	100
9.	Chloride as Cl, mg/L	250	1000
10.	Sulphate as SO_4, mg/L	200	400
11.	Nitrate as NO_3, mg/L	45	No relaxation
12.	Dissolved oxygen,mg/L	6	-
13.	Fluoride as F, mg/L	1	1.5
14.	Zinc (as Zn), mg/L	5	15
15.	Iron as Fe, mg/L	0.3	No relaxation
16.	Lead (as Pb), mg/	0.01	No relaxation
17.	Arsenic (as As), mg/L	0.01	0.05
18.	Total coliform Bacteria	-	Shall not be detectable in any 100 ml sample
19.	E. coli	-	Shall not be detectable in any 100 ml sample

Physico-chemical and microbiological analysis of drinking water sampling done regularly in first week of each month from May to October 2017and samples were collected at thirty days interval.
Bottles were properly labeled with sample number and well rinsed with the sample water to be collected. Hand pumps and tube wells were permitted to flow continuously for around 10 min before sample collection
Analysis of samples were carried out as per the standard methods of APHA [3]. The Data obtained were statistically analyzed using mathematical standards.

RESULTS AND DISCUSSION

The physico-chemical and microbiological parameters were determined for evaluating quality of water. The average value of physico-chemical and microbiological parameters of water during study is given in table 2.

Table 2: Average values of water quality at various sampling location at Morena

Parameters ↓ / Location → / Source →	S1 / TW	S2 / HP	S3 / TW	S4 / HP	S5 / BW	S6 / HP	S7 / HP	S8 / HP	S9 / BW	S10 / HP
Temperature, ^{0}C	33.1± 1.85	33.3± 1.90	34.5± 2.02	35.6± 2.04	33.5± 1.92	33.3± 2.02	32.8± 1.70	33.3± 1.66	32.3± 1.20	33.1± 1.66
pH	7.9± 0.08	7.4± 0.13	7.7± 0.11	7.7± 0.09	7.4± 0.06	7.7± 0.07	7.9± 0.05	7.7±0.1	7.6± 0.01	7.7± 0.04
Conductivity, µS/cm	938.5± 5.74	856± 14.04	929.6± 21.28	1087.3± 11.68	807.3± 13.13	583± 30.95	809.5± 20.06	1280.3± 80.38	832.3± 12.06	1228.5± 16.15
Total dissolved solid,mg/l	542.3± 7.23	597.6± 7.04	620.6 ±11.8	651.5± 19.7	480.5± 8.06	403.3± 5.88	496± 13.70	742.5± 20.21	495.1± 20.25	817± 22.26
Total alkalinity, mg/L	189.1± 14.4	191.2± 5.47	326.9± 5.08	280.0± 4.68	278.2± 16.72	201.7± 20.5	200.7± 3.81	422.7± 30.21	194.5± 1.52	380.3± 47.63
Total hardness, mg/L	299.4± 16.6	324.2± 25.3	344.7± 23.2	371.9± 16.3	277.7± 4.37	234.1± 4.63	297.7± 16.71	435.1± 8.35	259.1± 7.23	438.6± 15.40
Chloride, mg/L	47.0± 4.44	44.1± 6.57	51.7± 6.34	79.9± 1.15	51.9± 6.52	41.7± 6.37	43.4± 6.67	55.4± 8.81	43.4± 5.39	92.6± 2.72
Sulphate, mg/L	14.8± 1.05	14.7± 1.29	17.8± 2.59	25.1± 1.05	14.9± 1.43	14.3± 1.68	14.5± 1.58	43.0± 1.31	14.3± 0.81	37.1± 2.54
Nitrate mg/L	0.16± 0.0082	0.21± 0.027	0.17± 0.019	0.29± 0.126	0.26± 0.043	0.16± 0.013	0.14± 0.009	0.17± 0.014	0.16± 0.013	0.16± 0.009
DO mg/L	6.26± 0.149	6.87± 0.101	6.58± 0.138	6.15± 0.135	5.27± 0.198	4.94± 0.062	5.97± 0.055	6.01± 0.164	5.53± 0.099	6.16± 0.092
BOD, mg/L	0.99± 0.024	0.61± 0.028	0.65± 0.038	0.81± 0.012	1.04± 0.019	0.80± 0.048	1.10± 0.032	0.91±0. 031	1.19± 0.026	1.08± 0.035
Fluoride, mg/L	0.72± 0.025	0.75± 0.023	0.92± 0.049	0.86± 0.027	0.69± 0.018	0.84± 0.024	0.74± 0.022	0.77±0. 022	1.02± 0.057	0.81± 0.030
Iron as Fe, mg/L	0.24± 0.012	0.25± 0.019	0.41± 0.062	0.36± 0.067	0.32± 0.032	0.26± 0.025	0.25± 0.002	0.46± 0.045	0.44± 0.052	0.39± 0.043
Zinc as Zn, mg/L	0.24± 0.015	0.25± 0.015	0.36± 0.013	0.33± 0.031	0.40± 0.026	0.50± 0.020	0.40± 0.025	0.41± 0.007	0.44± 0.028	0.44± 0.044
As mg/L	0.0002± 0.000	0.0009± 0.000	0.0003± 0.000	0.0014± 0.000	0.0005± 0.000	0.0012± 0.000	0.0015± 0.000	0.0015± 0.000	0.0009± 0.000	0.0024± 0.000
Lead as Pb, mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total coliform MPN/100ml	0	0	0	0	0	0	0	0	0	0
E.coli, MPN/100ml	0	0	0	0	0	0	0	0	0	0

BDL (below detection limit)

Temperature

Temperature plays an important role in the aquatic ecosystem as it regulates the metabolic activities in microorganism [7]. Moreover, increase in temperature also reduces the quality of water in terms of taste, odor and also increases the problem (WHO). In the present study lower average value of temperature was recorded 33.1 at site S1 and highest were recorded 35.6 at site S4.highest value of temperature of ground water obtained in month of May and June.

pH:
H_2Sreleased in to the atmosphere by decreasing pH and by increasing pH the growth of plants is reduced [6], pH value of ground water sample in the study area were ranged from 7.44 at site S5 and 7.92 were highest at sites S_1.

Electrical Conductivity:
Electrical Conductivity is determine the concentration of ions present in water. [15]. During the study the lowest value was recorded 583µS/cm at site S6 and highest was 1280.3 µS/cm at site S8.

Total dissolved solid:
The amount of dissolved solids in water indicates the salinity behavior of groundwater. Water containing more than 500 mg/L of TDS is not considered for drinking water, but in unavoidable cases 1500 mg/L is also allowed [9], During the study Minimum total dissolved solid was recorded 403.3mg/Lat site S6 while highest were recorded 817 mg/L at site S10.

Total alkalinity:
The potential of water to react with or to neutralized acid is determined by alkalinity. Acceptable limit of total alkalinity is 200 mg/Land permissible limit is 600 mg/L according to BIS.The amount of total alkalinity of samples were found in between 189.19mg/L to 380.33 mg/L The lowest value was recorded at site S1 and higher was found at site S10.

Total hardness:
The concentration of cations of $Ca^{2+}$and Mg^{2+}determines the hardness of water. Hardness of all samples were analyzed during the study and lowest value of hardness recorded at site S6 which was 234.13mg/L while highest value of total hardness was438.60mg/L at site S10.

Chloride:
The presence of chloride in water imparts of salts and deteriorates quality of water which is unacceptable for drinking. Although, higher concentration of salt may be cause of deleterious effect on the human health. During the study lowest value 41.73 mg/L of chloride was recorded at site S6 and higher value 92.64mg/L was recorded at site S10which indicate that the quality of water in terms of chloride is under the limit.

Sulphate:
The importance of sulfate ions in the drinking water can't be ignored as it is very essential for the formation of proteins, its deficiency may cause pain and inflammation associated with various muscle and skeletal disorders [21]. In the current study, concentration of sulphate ranged from 14.30mg/L to 43.06mg/L. All the samples were found within the limit, lowest value recorded at site S9 and higher value was obtained at site S8 during the investigation.

Nitrate:
The cause of concern for nitrate in the drinking water is the occurrence of blue baby syndrome in infants and should not be above 10 mg/L of WHO. The main source of nitrates in the drinking water is due to synthetic fertilizers. The concentration of nitrate in the ground water was in the range of 0.14mg/L to 0.292mg/L which was under the limit.

Dissolved Oxygen:
It is the amount of oxygen dissolved in water and which is important for aquatic biodiversity. The undesirable odour, taste are caused due to low concentration of dissolved oxygen in water and it was an important parameter for understanding the water quality. Lowest value of 4.94mg/L at site S6 and higher value of 6.87mg/L at site S2 were recorded during this study.

Biochemical Oxygen Demand:
BOD is a measure of organic material contamination in water and is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials [12]and also used for the assessment of water quality. Lowest value 0.61mg/Lat site S2 and higher1.19mg/L at site S9 found at the sampling area which was under permissible limit of BIS 2012.

Fluoride:
Excess quality of fluoride in water is cause of fluorosis. [17]. In the present study lowest value of fluoride recorded0.69mg/L at site S5 and higher value was found1.02mg/Lat site S9 during the study period.

Iron:
The Iron is a natural element present in the earth crusts water passes through rocks and get dissolved as minerals forms into water bodies. Corrosion and deterioration of old iron pipes may also be the source of iron in water. Lowest value of 0.24 at site S1 and higher value of 0.46 at site S8 were observed by spectrophotometrically.

Zinc:
Zinc is a very essential micronutrient in human beings but at high concentration may cause toxic effects. The maximum permissible concentration of zinc in drinking water is 15 ppm [21]. Present study evaluated that lowest value of zinc is 0.24mg/L at site S1 and higher value of 0.50mg/L were at S6

Arsenic:
Arsenic is mainly through intake of food and drinking water, itis related to increased risk of skin cancer, hyperkeratosis and pigmentation changes. Intake of 70to 80 mg of trivalent arsenic (III) oxide is reported very fatal for man [20]. Lowest value of 0.0002 at site S1 and higher value of 0.0024 at site S10 was observed at the study area.

Lead:
Lead is toxic to the central and peripheral nervous system causing neurological and behavior effects and may cause hearing loss, blood pressure etc. In the present study, lead concentration in below detection limit, as prescribed by BIS (Table I).

Total coliform:
The MPN of total coliforms bacteria were determined by multiple tube fermentation technique. Total coliform was not present at all the sampling during the course of studies.

E.coli:
The presence of *E.coli* in drinking water may cause diarrhoea, cramps, nausea, headaches etc [2].In the present investigation, *E. coli* bacteria were not found at all the sampling stations.
Correlation matrix of all physico-chemical and microbiological parameters were analyzed during study shown in (Table 3).

Table 3: Correlation among the estimated water quality parameters

Parameters	Temp	pH	con	tds	TA	TH	Cl	SO4	NO3	DO	BOD	F	Fe	Zn	As
Temperature, ^{0}C	1	-0.03	0.24	0.26	0.28	0.31	0.44	0.14	0.70	0.27	-0.58	0.07	0.12	-0.26	-0.08
Ph		1.00	0.13	0.02	-0.01	0.08	0.05	0.10	-0.51	0.00	0.31	-0.04	-0.14	0.03	0.12
Conductivity, µS/cm			1.00	0.95	0.81	0.96	0.72	0.89	0.09	0.47	0.08	-0.05	0.60	-0.15	0.47
Total dissolved solid,mg/l				1.00	0.80	0.98	0.77	0.87	0.05	0.57	-0.09	-0.01	0.54	-0.13	0.55
Total alkalinity, mg/L					1.00	0.85	0.62	0.89	0.07	0.15	-0.04	-0.02	0.71	0.26	0.44
Total hardness, mg/L						1.00	0.74	0.91	0.07	0.53	-0.10	-0.10	0.52	-0.10	0.56
Chloride, mg/L							1.00	0.67	0.33	0.20	0.10	0.04	0.38	0.08	0.64
Sulphate, mg/L								1.00	-0.02	0.17	0.07	-0.05	0.62	0.21	0.66
Nitrate, mg/L									1.00	0.01	-0.27	-0.15	0.01	-0.28	-0.13
DO, mg/L										1.00	-0.48	-0.08	0.01	-0.75	-0.06
BOD, mg/L											1.00	0.02	0.16	0.40	0.27
Fluoride, mg/L												1.00	0.59	0.35	0.02
Fe, mg/L													1.00	0.38	0.23
Zn, mg/L														1.00	0.48
As, mg/L															1.00

The table 4 gives a comparative perception of water related issues and water borne diseases in Morena city. Although, very less water borne diseases were reported by the people as nobody reported that they are suffering from diarrhoeal diseases in the age group of 15-30 years but 6.25% people in the age group of 31-60 reported that they suffer from diarrhoeal disease 5- 10 times in a year. Most of the people also indicated other water related issues in the area as indicated in the table.

CONCLUSION

The results of physico-chemical and microbiological analysis of groundwater Morena city showed that ground water was within the limit according to (Bureau of Indian Standards 10500:2012). However, at various sites the values were above the standards as proposed by BIS that may expose the consumers to different water borne diseases like diarrhoea, vomiting, dysentery, etc. Proper legislation and Government policies need to be implemented in order to provide safe drinking water to the consumers. Education and awareness to the residents in the Morena city will play a pivotal role in order to reduce the burden of water borne diseases.

Table 4: Perceptions of water related issues and water borne diseases

Questions		Age Group		
		15-30 N = 16	31-60 N = 71	61-90 N = 13
Are you aware about water pollution	Yes	8 (50)	22(30.98)	5(38.46)
Do you live in this colony/sector throughout the year	Yes	15 (93)	70(98)	13(100)
What is your level of education?	Primary	2 (12.5)	19(26.76)	2(15.38)
	Upper primary	8 (50)	29(40.84)	3(23.07)
	Upper secondary education	4 (25)	14(19.71)	4(30.76
	Post-secondary non-tertiary education	2(12.5)	9(12.67)	1(7.69)
If your water comes from a municipal supply, what is the source of that supply? Please choose one.	Ground Water	16(100)	71(100)	13(100)
	Dam, reservoir, lake or river	0	0	0(0)
	I am not sure	0	0	0(0)
Which of the following sources of drinking water does your household use?	Municipal water	0	1(1.40)	0(0)
	Private Water well	0	0(0)	0(0)
	Bore well/Hand Pump	16(100)	70(98)	13(100)
	Packaged water	0	0(0)	0(0)
	Surface water	0	0(0)	0(0)
What is the frequency of water supply?	24 hour supply	13(81.25)	70(98)	13(100)
	More than once a day	0	1(1.40)	0(0)
	Once a day	0	0(0)	0(0)
	Once in two days	3(18.75)	0(0)	0(0)
	Once in three days	0	0(0)	0(0)
	One in a week	0	0(0)	0(0)
How would you evaluate the quality of your drinking water?	Poor	0	1(1.40)	0(0)
	Very Good	0	0(0)	0(0)
	Satisfactory	16(100)	70(98)	10(76.92)
	Excellent	0	0(0)	0(0)
Do you have any issue related to water?	Nil	14(87.50)	66(92.95)	13(100)
	Taste	1(6.25)	2(2.81)	0(0)
	Odor	0	2(2.81)	0(0)
	Colour	1(6.25)	0(0)	0(0)
	Any other	0	1(1.40)	0(0)
Do you think any external factors are affecting your water quality?	Yes	5(31.25)	35(49.29)	4(30.76)
	No	11(68.75)	36(50.70)	8(61.53)
Do you use any treatment?	Yes	1(6.25	19(26.76)	3(23.07)
	No	15(93.75)	52(73.23)	10(76.92)
Which months do you face scarcity?	Nil	1(6.25))	71(100)	13(100)
	None	15(93.75)	0(0)	0(0)
Did you suffer from drinking-water related diarrhea?	None	15(93.75)	48(67.60)	11(84.61)
	< 5 times	0	17(23.94)	2(15.38)
	5- 10 times	1(6.25)	6(8.45)	0(0)
	> 10 times	0	0(0)	0(0)
Do you have health problems due to water?	Yes	6(37.5)	36(50.70)	5(38.46)
	No	10(62.5)	35(49.29)	8(61.53)
Overall, are you satisfied with your drinking water service?	Yes	10(62.5)	36(50.70)	8(61.53)
	No	6(37.5)	37(52.11)	5(38.46)
You want to give any other information related to drinking water?	0	0	0	0

Note: Values in Parentheses represents percentage of Number andN=Number of represents

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