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Analysis of physico-chemical characteristics of ground water in Mant Tehsil of Mathura District of U.P. (India)

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Abstract
The physico–chemical characteristics of ground level water have been studied in Mant tehsil of Mathura district of Uttar Pradesh (India). Water samples from 20 bore wells at various locations were collected and analyzed for pH, electrical conductivity, dissolved oxygen, total dissolved solids, total alkalinity, chloride, fluoride, nitrate, phosphate, Na, K, Ca and Mg. Mostly all the samples of water were containing chemical constituents beyond permissible limits prescribed by WHO. The study indicates the need for periodic monitoring of ground water in the study area. This study shows that the quality of ground level water varies from well to well. Higher values of certain parameters at certain bore wells indicate that the water of those bore wells are not suitable for drinking. Based on these findings, it can be recommended that any ground water source in the study area should be tested before use for its suitability and usefulness for daily purpose.

Keywords: ground water, contamination, physico-chemical analysis, Mant Tehsil, Mathura

Introduction
"Water for life" is a true saying for the existence of life. Two third of the earth's surface is covered by water, but the quantity of potable water is very limited. There are various source of potable water, but the ground water is Considered to be most suitable. But now-a-days, even the ground water become unsafe for drinking purposes. The quality of ground water is influenced by the nature of the surface as well as the environment where the recharge takes place.
The water used for industries, agriculture and human needs, adds continuously contaminants to the ground water. The indiscriminate disposal of industries and municipal wastes makes the ground water susceptible to pollution. It is reported that two third of all illness in India are related to water borne diseases.
Thus, it becomes necessary to examine the quality of water from time to time so that proper measures can be taken. The present research is an attempt to check the quality of water in the Mant tehsil of Mathura district of Uttar Pradesh (India). Hence, seepage of domestic sewage and industrial effluents is likely to affect the quality of ground water. So, in the light of this, an attempt has been made to study the quality of ground water in and around Mant tehsil of Mathura district of Uttar Pradesh (India). Recently the ground water analysis has been carried out by some Scientist [1, 2]

Material and Methods
Twenty bore wells were selected from different locations in the study area. Sampling was done during Jan. 2020 to Sept. 2021 on monthly basis. Water samples from identified bore wells were collected in precleaned sterilized two liter polythene bottles and were analyzed for fourteen parameters: pH, electrical conductivity (EC), dissolved oxygen (DO), total hardness (TH), total dissolved solids (TDS) , total alkalinity (TA), calcium (Ca^{2+}), potassium (K^+) , chloride (Cl^-), fluoride (F^-), nitrate (NO^{-}) and phosphate (PO_4^{3-}) ions. The physico-chemical analysis was carried out according to standard methods. Chloride, fluoride and nitrate were analyzed using Thermo Orwn 720 ion analyzer. Sodium and potassium was determined using ELEICO- CL 360 flame photometer.

Results and Discussion
The analytical data and statistical calculations related to the physio-chemical characteristics of the analyzed water samples have been presented in the Table-1. A comparison of the physio-chemical characteristics of the analyzed ground level water samples has been made with WHO (1997)[3] for drinking water standards (Table- 2).

pH value
pH governs the solvent properties of water and it determines, the extent & type of physical, biological & chemical reactions likely to occur within a water system or between the water & surroundings, rocks, & soils.

The pH of most natural waters falls approximately within the range of 4.5 - 8 depending on the concentration of carbonate, bicarbonate and hydroxyl ions present. Alkaline water is generally more common than acidic waters. The present study indicates that the water samples from majority of bore wells are alkaline with pH range 5.9 to 7.2. The recommended value for drinking water is between 6.7 to 8.5. So the pH value of all the water samples is well within permissible limit.

Table 1: Physico-chemical characteristic of ground level water in Mant tehsil (Mathura)

Bore Well No.	Depth (m)	pH	EC	DO	TH	TDS	TA	Ca2+	Mg2+	Na^+	K^+	Cl^-	F^-	NO^-	PO_4^{3-}
1	78	7.4	1202.6	5.9	354.3	743.7	237.4	94.9	29.4	92.4	2.9	128.6	0.52	10.0	0.02
2	67	6.9	1296.6	5.6	365.4	792.8	168	72.6	23.7	73	7.3	84	0.32	7.0	0.06
3	56	7.3	1293.5	6.0	510	951.5	302.9	139.1	39.8	113.6	0.9	242.6	0.41	1.5	0.04
4	76	6.8	1336.3	5.6	513	826.6	190	122	49.8	111.4	7.8	241.8	0.40	32	0.06
5	85	7.1	881.7	5.6	298.6	586.9	228.6	76.0	26.6	57.2	3.4	129.5	0.39	31	0.04
6	65	6.9	1348.7	5.8	989.1	2017.1	392	354.3	107	169	9.8	693	0.34	1.5	0.0
7	72	6.7	1122.7	6.0	370.6	829.5	270	93.9	37.8	115.3	6.6	2.0	0.37	9.8	0.0
8	81	7.2	962.4	5.7	320	795.1	292.9	85.5	26.6	107.5	10.5	188.5	0.24	8.8	0.09
9	78	7.1	1157.5	6.0	288	508.3	178.6	64.1	26.4	69.4	1.3	109	0.26	11.8	0.04
10	76	6.9	3153.4	6.2	650	694.5	290.5	154	64.9	78.2	4.3	190	0.19	12.0	0.02
11	74	7.2	578.6	5.6	152.6	398.2	110.9	41.8	13.2	50.8	3.2	90.3	0.27	8.0	0.04
12	69	6.8	914.4	5.7	271.4	570.8	245.1	69.7	24.5	72.5	3.8	98.8	0.48	8.5	0.02
13	68	7.1	1324.1	5.8	789.9	816	546.2	128	44.5	70.2	3.2	84.5	0.42	31.0	0.06
14	82	7.3	1534.5	6.1	375	920.7	228	90	37.6	109.5	4.3	150.2	0.22	16.0	0.05
15	86	6.8	902.1	5.4	255.7	556.8	178.6	66.9	21	78.8	2.5	102	0.04	10.0	0.07
16	68	6.9	720.1	6.0	190	443.1	200	47.4	18.6	56.3	2.2	64.3	0.42	11.0	0.0
17	69	7.0	1579.1	5.8	398.6	989	482.6	98.8	37.1	140.8	2.7	212.2	0.82	3.0	0.02
18	64	7.3	1021.0	6.1	203.8	626	201.4	76	25.8	65.9	2.2	119	0.13	8.0	0.06
19	84	6.9	2497.7	5.7	675	1598.5	365	160	67.9	112.5	1.9	552	0.37	5.0	0.08
20	79	7.1	2244.6	5.9	527.8	1399.5	225.7	178.3	43.5	162.3	1.3	491.9	0.71	31.0	0.01

All parameters are expressed in mg/L, except pH and EC (in micro Siemens/cm).

Table 2: Comparison of ground water quality of the studied area with the WHO drinking water standards

Parameters	WHO Standards (1997)				Observed value	
	P	E	P	E	Min.	Max.
pH	7.0-8.5	6.5-9.2	5.0-8.5	6.5-9.2	6.7	7.4
TDS	500	1500	500	2000	358.2	2017.1
TH	-	-	300	600	152.6	1289.1
EC	-	-	-	-	578.6	3153.4
TA	-	-	-	-	110.9	546.2
DO	-	-	-	-	5.0	6.3
Ca2+	75	200	75	200	41.1	354.9
Mg2+	50	150	30	100	13.2	107.1
Na+	200	-	150	-	50.8	169.0
K+	-	-	-	-	0.9	14.1
Cl–	200	600	250	1000	63.6	693.0
F–	0.5	1.0-1.5	0.6-1.2	1.5	0.0	0.82
NO3–	50	100	45	100	1.5	32
PO43–	-	-	-	-	0.0	0.09

Note; P = Permissible limit, E = Excessive limit
All parameters are expressed in mg/L (ppm), except pH and conductivity (microSiemens/cm).

Electrical conductance (EC)

The EC serves as useful indicator of the degree of mineralization of water samples. Its value depends on the concentration and degree of dissociation of the ions, type of ions as well as their migration velocity in the electric field. The EC values ranged from 542.2 to 3092.1 micro Siemens/cm. EC has been found to be higher in deeper bore wells [4]. The EC values obtained are well correlated with TDS.

Dissolved oxygen (DO)

Dissolved oxygen (DO) values show the ability of the ground water to purify itself through biochemical processes [5]. Low content of DO is an indication of organic pollution, particularly when pollution is contributed by sewage. High depletion in oxygen content produces foul odour due to the anaerobic decomposition of organic waste leading to the evolution of hydrogen sulphide (H_2S). In the present study, the DO content is ranging between 5.2 to 6.6 Mg/ litre.

Total dissolved solids (TDS)

Total dissolved oxygen (TDS) of water includes all soluble materials in solutions whether ionized or non-ionized. The dissolved solids originate from the weathering of rocks, soil and dissolving lime, gypsum and other salt sources as water percolates through them [6]. Ground water quality changes as the water flows through the subsurface, geological environment increasing dissolved solids and major ions [7]. TDS indicate the general nature of water quality of salinity. The TDS values in the study areas varied from 372.4 to 1877.5 mg/liter. Except three locations, the TDS content was found to be well above the WHO and ISI permissible limits (500 mg/liter). Water with greater TDS than 1500 mg/liter is unfit for domestic applications. Few bore wells show greater TDS than 1500 mg /liter and hence, the water is not suitable for domestic purposes. The increase in TDS may be due to contamination of ground water from municipal waste. Further, these are deep bore wells (> 80 m) and it has been reported that major ion concentrations strongly correlate with depth4. The ground water is non-saline, if TDS is less than 1000 mg/litre and saline, if in the range 1000-3000 mg/liter [8]. Accordingly, water from 16 bore well of study area is non-saline and that from four bore wells is saline.

Total hardness (TH)

Hardness is caused by dissolved divalent metallic cations mainly Ca^{2+}, Mg^{2+}, Sr^{2+}, Fe^{2+} and Mn^{2+} ions. In the present study, the TH ranged from 139.5 to 1012.3 mg/litre. This indicates that only six locations have TH contents within ISI permissible limits (300 mg/litre). The TH values obtained very well correlate with TDS.

Chloride

Chloride (Cl^-) ions occur in all natural water in widely varying concentrations. The origin of chloride in surface and ground water may be from diverse sources such as weathering and leaching of sedimentary rocks and soils, infiltration of sea water, domestic & industrial waste discharge, municipal effluents etc. Excessive chloride in potable water is not particularly harmful and the criteria set for this anion are based primarily on palatability and its potentially high corrosiveness. Chloride ions in excess (> 250 mg/lit) imparts a salty taste to water and people, who are not accustomed to high chlorides may be subjected to laxative effects [9]. The chloride content in the study area ranged between 50.5 to 546.0 mg/lit. The WHO and ISI permissible limit of chloride for drinking water is 200 to250 mg/lit, respectively. The chloride value of the water samples studied in well is within permissible limit of WHO for 14 bore wells and that of ISI for 18 bore wells. However, all the values are well within the excessive limit of ISI (1000 mg/lit). The high value of chloride may be attributed to the seepage of domestic and industrial effluents.

Fluoride

Fluoride is a geochemical contaminant and natural sources account for much of the fluoride found in surface and ground waters. The concentration of fluoride in these water depends principally on the solubility of the F– containing rocks with which the water is in contact. Intake of excess fluoride causes dental and skeletal fluorosis but also non-skeletal fluorosis through continued use of fluoride contaminated water, air and agricultural produce [10]. Fluoride content in the study ranged from 0.0 to 0.62 mg/lit, which is well within the permissible limit (0.6 to 1.2 mg/lit) of ISI standards for safe drinking water.

Sodium and potassium

These are naturally occurring ions in ground level water as a result of weathering of rocks and minerals. Industrial and domestic wastes also add sodium to ground water. Excessive amount of sodium in drinking water affects the palatability of water and water containing up to 100 mg/lit may generally be physiologically tolerable, relatively high concentration of sodium may adversely affect soil structure and permeability resulting in alkaline soils.

The Na content in the study area ranged from 40.3 to 150.9 mg/lit which is well within the WHO permissible limits (200 mg/lit). Despite its abundance in nature, K is found in relatively small concentration in most natural water mainly because of its being reconverted into insoluble secondary minerals formed in the process of weathering.

K is an essential nutrient for both plant and animal life. However, ingestion of excessive amounts (2000 mg/lit) may prove detrimental to the human nervous and digestive systems [11]. The K content in the study area ranged between 0.6 to 12.2 mg/lit.

Total alkalinity (TA)

The total alkalinity (TA) in natural water system is manually due to carbonates, bicarbonates and hydroxides. These constituents are the results of dissolution of minerals in the soil and atmosphere [14]. Carbonates and bicarbonates may originate from microbial decomposition of organic matter also. In the present investigation, the total alkalinity was found in the range of 98.2 to 490 mg/lit

Calcium and Magnesium

Calcium and Magnesium (Ca^{2+} and Mg^{2+}) are the most abundant ions in natural surfaces and ground water and exist mainly as bicarbonate and chloride. The level of calcium and magnesium salts regulates the hardness of water bodies. In the present study, Ca^{2+} content ranges from 31.1 to 258.8 mg/liter. For 12 bore wells, Ca^{2+} content is well within WHO and ISI permissible limit (75 mg /liter). For 8 bore wells, it is within the excessive limit (200 mg/liter). This may be derived from contacts of ground water with sedimentary rocks particularly calcite , dolomite and gypsum .The Mg^{2+} content, which ranged from 10.8 to 103.2 mg/liter, is well within the excessive limit (150 mg/liter) specified by WHO.

Nitrate

The presence of nitrate in water is due to domestic activities and agriculture run off, which dissolved in rain water leaching into the wells [13]. The determination of nitrate is important particularly in drinking water as it has adverse effects on health above 50 mg/liter3. Nitrate is basically non-toxic but when ingested with food or water, it will be reduced by bacterial action to nitrate and then to NH3, which are toxic.

$$NO_3^- + 2H^+ + 2\,e^- = NO^-_2 + HO_2$$

$$NO_2^- + 8H^+ + 6\,e^- = NH^+_4 + 2\,HO_2$$

$$NO_3^- + 10\,H^+ + 8\,e^- = NH_4^+ + 3\,H_2O$$

Also, nitrite has greater affinity for oxygen than hemoglobin of blood. It gets oxygen from blood to be oxidized to nitrate. The depletion of oxygen in blood causes suffocation and ultimately, death. In the present study, the NO3– was found to be between 1.2 to 28 mg/lit., which is well within the permissible limit of WHO and ISI.

Phosphate

(PO_4^{3-}) content in ground water in general is due to the leaching from mineral ores, agriculture run off and municipal sewage due to utilization of synthetic detergents [12]. Also combustion of organic materials, industrial waste gases, and fossil fuel burning may add phosphates to water. Phosphate is essential for bones and some enzymatic systems. The phosphate in low concentrations may not cause any harm to man and animal. But, if phosphate is consumed in excess, phosphin gas is produced in gastrointestinal tract on reaction with gastric juice. This could even lead to the death of consumer. In the present investigation, the phosphate content varied between 0.0 to 0.06 mg/lit.

Conclusion

The outcome of this study shows that the quality of ground level water varies from well to well. Higher values of certain parameters at certain bore wells indicate that the water of those bore wells are not suitable for drinking as such. Based on these findings, it can be recommended that any ground water source in the study area should be tested before use for its suitability and usefulness for daily purpose. The result of this study indicates that the quality of ground level water varies from well to well. Higher values of certain parameters at certain bore wells indicate that the water of those bore wells are not suitable for drinking as such. So it is suggested that any ground water source in study area should be analyzed before use for its suitability for domestic purposes. The result also suggests that contamination problem is not alarming at present but ground water quality may deteriorate with time. Hence, proper care must be taken to avoid any contamination of ground water and its quality be monitored periodically.

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