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ASSESSMENT OF WATER QUALITY INDEX OF PRATAPGARH DISTRICT OF UTTAR PRADESH, INDIA

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ABSTRACT

Deterioration of ground water resources has long been a major concern of human society, when the aim is to preserve and maintain balanced biological communities and sustainable stream ecosystem health. The sustainable use of ground water resources in India and other countries require the development of more powerful tools, to assess the water quality and health of ground water. Development of an index for this purpose is critical for improving ground water management. WQI were developed based on eight important water qualities parameters covering seventeen blocks in study sites in Pratapgarh district of Uttar Pradesh. The five hundred seventeen ground water samples were collected from diffrent tehsils of Pratapgarh district covering Aashpurdevosara, Sangramgarh, Babaganj, kunda, Patti, Lalganj, Sandwachandika, Sadar, Sangipur, Gaura, Vihar, Belkharnath, Sivgarh, Mandhata, Mangraura, Kalakankar and Laxmanpu . The samples were collected from handpump, and tubewell during the November, 2013 from various abstraction sources at variable depths covering extensively cropped area. The study show the presence of Nitrate in the ground water in different water sample but it does not exceeds BIS (2012) standard for except at Sadar Block, Concentration of nitrate (NO_3^-) in the analysed water samples varies between 0 and 46 mg L^{-1} . Further chemical analysis reveals that two samples out of five hundred seventeen have more than permissible limit of Fluoride concentration as per WHO(2011) and Indian standards. A water Quality Index (WQI) rating was carried out using parameters to quantify the overall groundwater quality status of the area.

Keywords: *Hydro-chemical, WQ Index, Irrigation, Drinking*

INTRODUCTION

India is a vast country with varied hydrogeological, situations resulting from diversified geological, climatological and topographic settings. Water-bearing rock, formations (aquifers) range in age from Archaean to Recent. The natural chemical composition of ground water is influenced predominantly by type & depth of soils and subsurface geological, formations through which ground water passes (Kumar and Rakshit, 2014).

Groundwater in India, is used for several purposes including drinking water and agricultural, municipal and industrial, supplies. The changes in human population often correspond with change in land use, including expansion of urban areas, agriculture and increasing industrialization, which necessitate increasing the available amount of drinking water (Verma and Rakshit, 2012). The term "water quality" includes the water column and the physical channel required to sustain aquatic life. The quality of water is defined in terms of its physical, chemical and biological parameters, and ascertaining its quality is crucial before use for various intended purposes such as potable water, agricultural, recreational and industrial water uses, etc. (Sargaonkar and Deshpande, 2003). The major hazard in drinking water supplies is microbial contamination, which is due to agricultural land wash, domestic sewage, industrial effluents, improper storage and handling. Primary contamination in drinking water is improper storage of water supply, water storage and leakage of pipes and secondary contamination due to manmade such as improper handling, storage, distribution and serving methods .As the surface water sources are under the pressure of pollution, it has become necessary to use groundwater at an increasing rate. Groundwater recharge can be abundant in the alluvial plains, where the urban areas are often located. Such areas can face danger of pollution of groundwater, and the changes in land use are likely to result in change in groundwater quality (Bharti and Katyal,2011). In this region ground water, is the major source of water for drinking, agricultural, and industrial desires.

Ground water quality is also influenced by contribution from the atmosphere and surface water bodies. Water is the precious natural resources for the sustaining of life, on this planet. Because water is the very important element of our body, about 70% of our body is made up with water due to the climate change and hydric stress that makes the unavailability clean water for human consumption(Al-Shujairi,2013). Present decisions relative to the management of hydric resources will deeply affect the economy and our future environment. The use of indicators, is a good alternative for the evaluation of environmental behaviour, as well as a management instrument, as long as the conceptual and structural parameters of the indicators are respected. India's average annual precipitation is nearly 400 million hectare meter, (mha-m) of which only 50 mham, enters the groundwater table (Bhaskar and Nagendrappa, 2008).

The availability of water determines the location and activities of humans, in an area and our growing population, is placing great demands upon natural fresh water resources. Groundwater is about 20% of the world resource of fresh water and widely used for various purposes. Only about 1% of all of fresh water is available from rivers, ponds, lakes. Use of ground water for various purposes are mainly depends upon its intrinsic quality of water, hence it is prime important to know the quality of water resources in the region. The people of India depend upon groundwater resources for survival. Rapid industrialization of India, has affected the availability and quality of ground water due to over exploitation, and improper disposal of waste in urban areas. The physico-chemical contaminants, that adversely affected the quality of groundwater, is likely to arise from a variety of sources, including land application of agricultural chemicals and organic wastes, infiltration of irrigation water, septic tanks, and infiltration of effluent from sewage treatment plants, pits,

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lagoons and ponds used for storage (Prasad et al., 2013). Water quality assessment plays an important role to control the pollutant sources of water bodies for the implementation of sustainable water use Sewage pollution, drainage, livestock production and fertilizers are the sources of anthropogenic stress on the aquatic environment, these activities pose threat to surface water bodies and also to ground water (Baghapour et al., 2013).

Large proportion of nitrogen gets converted into nitrate (NO_3) which being soluble in water and not retained by soil and leached to the ground water table. Nitrate in drinking water is associated with a number of health problems such as BBS (Blue Baby Syndrome), cancer, Alzheimer's disease in humans, intestinal disorders in pigs, etc. Nitrite (NO_2) has the ability to reacts with secondary amines present in human body and form carcinogenic nitrosamine. Ammonium (NH_4^+) is a critical water quality parameter and reported toxic to the organisms. Symptoms of NH_4^+ poisoning are restlessness, dullness, weakness, muscle tremors profuse salivation, vocalization, lung edema, tonic-colonic convulsion, and finally death by heart failure.

Phosphate (PO_4^{3-}) at high concentration in surface water bodies accelerate the growth of microscopic (algae) to macroscopic (macrophytes) and excessive growth of these aquatic plants can causes eutrophication and this results in deficiency of dissolved oxygen (DO) which kills fishes, and other aquatic fauna. Toxicity of PO_4^{3-}in humans includes impaired renal function, rhabdomyolysis and tumorolysis Syndrome.

According to WHO(2011) organization, about 80% of all the diseases in human being are caused by water. The major problem with ground water is that once contaminated, it is difficult to restore its quality. Hence there is need and concern for protection and management of ground water quality. Enhancement of heavy metals contamination of the ground water is one of the serious eventualities. Some of the heavy metals considered as micronutrients become detrimental to human health when their concentrations exceed the permissible level of drinking water (Prasad et al., 2013).The quality in deeper aquifers also varies from place to place and is generally found suitable for common uses (Choudhury and Rakshit, 2012).

Understanding of the hydrogeochemical processes and pollutant source and regular monitoring of water quality are essential for sustainable development and effective management of groundwater resources of any region. Though, information on the groundwater quality status and impact of urban and industrial development on groundwater resources are available for some districts like Unnao, Ghaziabad,

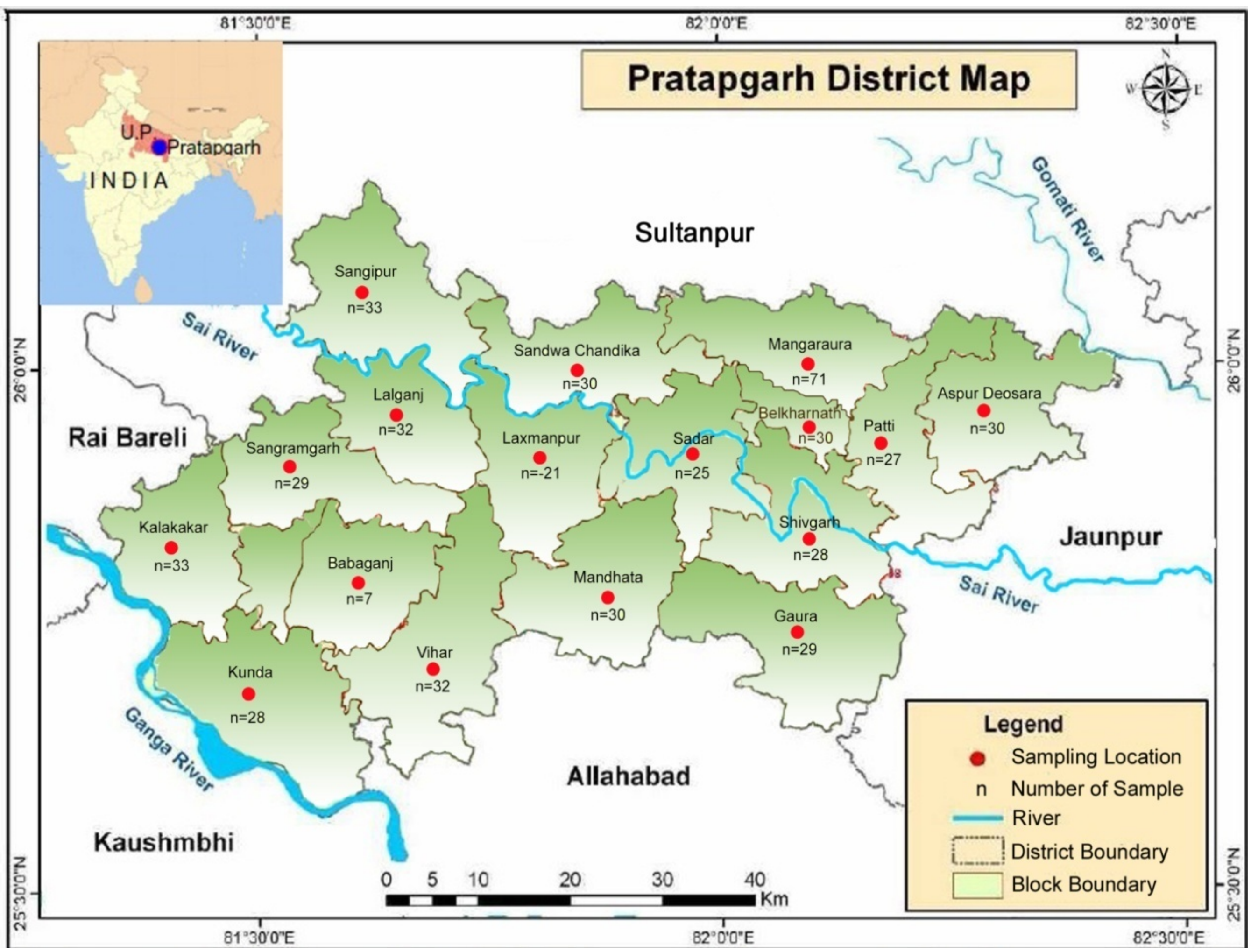

Fig1: Sampling locations in district of Pratapgarh, UP

Sonbhadra, Varanasi and Deoria (Singh et al., 2013) such information are lacking for many districts of Uttar Pradesh including Pratapgarh. In the present hydrogeochemical investigation, an attempt has been made to define the major ion chemistry and hydrogeochemical processes that control groundwater composition of the Pratapgarh district and to assess its suitability for domestic and irrigation uses. The study provides some basic hydro-geochemical data for rational exploitation and utilization of groundwater resources that may also help in future water resource planning for the area. Ground water quality index of the ground water samples was assessed using Water Quality Index calculator.

Water Quality Index

WQI's aim at giving a single value to the Water quality of a source reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data (Singh *et al*. 2013).Water Quality Index (WQI) is a technique of rating that provides the composite influence of individual parameter on the overall quality of water. WQI a well known method as well as one of the most effective tools to express water quality that offers a simple, stable, reproducible unit of measure and communicate information about water quality to the policy makers and concerned citizens (Singh *et al*. 2013). The weights for various water quality parameters are assumed to be inversely proportional to the recommended standards for the corresponding parameters. One of the major advantages of WQI is that, it incorporates data from multiple water quality parameters into a mathematical equation that rates the health of water quality with number (Brown *et al*. 1970). The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO(2011)), Bureau of Indian Standards (BIS(2012)), and Indian Council for Medical Research (ICMR).The weighted Arithmetic index method has been used for the calculation of WQI of the water body. Further quality rating or sub index was calculated using the following expression :

q_n=100(V_n-V_{io})/S_n-Vio)

(Let there be *n* water parameter and quality rating or sub index (q_n) corresponding to *nth* parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value)

where, q_n = Quality rating for the *nth* water quality parameter ,V_n = Estimated value of the *nth* parameter at a given sampling station ,S_n = Standard permissible value of the *nth* parameter and V_{io} = Ideal value of *nth* parameter in pure water. [i.e., 0 for all other parameter except the parameter pH and Dissolved oxygen (7.0 and 14.6 mg/l respectively]

While, unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter using the following expression:

W_n=K/S_n

where, W_n = Unit weight for the *nth* parameters, S_n = Standard value for *nth* parameters, K = Constant for proportionality.

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly using the following expression:

WQI= $\sum q_n W_n / \sum W_n$

Different levels of water quality index and their respective water quality status were given in Table 1. Various parameters and their unit weight were calculated and summarized in Table 2 with their standards and recommended agencies.

Table 1: Descriptive category of WQI values

Water Quality Index Level	Water Quality Status
0-25	Excellent Water Quality
26-50	Good Water Quality
51-75	Moderate Water Quality
76-100	Poor Water Quality
>100	Unsuitable for Drinking

Table 2: Drinking water standards recommending agencies and unit weights
(All values are in mg/L, except pH and Electrical conductivity)

S. No	Parameter	Standard	Recommended Agency	Unit Weight
1	pH	6.5 – 8.5	ICMR/BIS(2012)	0.219
2	Electrical Conductivity	300	ICMR	0.371
3	Total Dissolved Solids	500	ICMR/BIS(2012)	0.0037
4	Total Hardness	300	ICMR/BIS(2012)	0.0062
5	Total Suspended Solid	500	ICMR	0.0037
6	Calcium	75	ICMR/BIS(2012)	0.025
7	Magnesium	30	ICMR/BIS(2012)	0.061
8	Chloride	250	ICMR	0.0074
9	Nitrate	45	ICMR/BIS(2012)	0.0412
10	Sulphate	150	ICMR/BIS(2012)	0.01236
11	Dissolved Oxygen	5	ICMR/BIS(2012)	0.3723
12	BOD	5	ICMR	0.3723

MATERIALS AND METHODS

Pratapgarh is one of the oldest district of Uttar Pradesh, came into existence in the year 1858. It lies between 25°34' and 26°11'N latitudes and 81°19' and 82°27'E longitudes and covers a total area of 3,730 km^2. It has seventeen administrative blocks and total population of the district is 3,209,141 (India Census, 2011). Pratapgarh is bounded onthe north by Sultanpur, on the south by Allahabad, on the east by Jaunpur, on the west by Fatehpur and northeast by Rae Bareli districts. In the south-west, the Ganga river forms the boundary of the district for about 50 km separating Pratapgarh from Fatehpur and Allahabad districts and in the extreme northeast, the Gomti river forms the boundaryfor about 6 km.

The study area enjoys tropical climate with mild winter and long summer days. The area receives rainfall from the southwest monsoon lasting from Jun to September with a mean annual rainfall of 1180 cm, 85-90 percent of which is received during June to September and potential evapotranspiration (PET) is about 1400 mm. The temperature of the area varies from 4° C to 45° C. The temperature begins to rise from the middle of February and reached its maximum by the end of May or middle of June. The mean relative humidity is 62 percent which increases up to 85 percent from July to September and goes down to 20 percent from the end of April to first week of June.

Ground water samples were collected from different Blocks in Pratapgarh district namely Aashpurdevosara, Sangramgarh, Babaganj, kunda, Patti, Lalganj, Sandwachandika, Sadar, Sangipur, Gaura, Vihar, Belkharnath, Sivgarh, Mandhata, Mangraura, Kalakankar, Laxmanpur, The Five hundred seventeen samples are collected from handpump, during, November, 2013 from various abstraction sources at variable depths covering extensively cropped area. The hand pumps were continuously pumped prior to the sampling water to ensure that ground water to be sampled was representative of ground water aquifer and one liter of ground water samples was collected. The depth of sampling varied from 55-130 ft. It was ensured that the concentration of different ions draft change in time that elapse between drawing of samples analysis in laboratory. The water samples were collected in high density plastic bottles and preserved by toluene in laboratory for further analysis. All the samples were stored in sampling kits maintained at 4°C.

The physio – chemical characteristics of ground water samples were determined using standard analytical methods. The pH was measured with digital pH meters. Their electric conductivity was measured with a conductivity bridge using a standard potassium chloride solution for the calibration and determination of cell constant. The total degree of hardness and calcium plus magnesium was estimated by EDTA titrimetric methods. The total alkalinity, carbonate and bicarbonate were also estimated by titrimetric methods. The sodium and potassium were estimated by flame photometers and the chloride ions were estimated by Standard Silver Nitrate titration. The fluoride and nitrate contents in the ground water determined electrochemically, using EDT direct ion selective electrode methods and the ater quality index(WQI) was computed by a WQI calculator on the basis of the pH, temperature and nitrate parameters with their weighting factor.

RESULTS AND DISCUSSION

The physico-chemical and bacteriological quality of drinking water totally depends of the geological condition of the soil and ground water pollution of the area. A major objective of water quality assessment is to determine whether or not the water quality meets previously defined objectives for designated uses, to describe water quality at regional, national or international scales, and also to investigate trends in time, etc. The following are the important characteristic properties of ground water of determine its suitability for irrigation and domestic proposes.

Ground Water quality monitoring is being carried out through analysis of ground water samples collected from the handpump, the phreatic aquifers. The samples are collected during month of November, 2013 from different tehsils of Pratapgarh district, of Uttar Pradesh, with an objective of ground water exploration and management studies. The samples are analyzed for the physico-chemical, biological parameters and water quality index for evaluating the ground water quality and its suitability for various uses.

The observed pH values in the ground water samples of study area are ranged between 7 to 9.3 (Table 3) which comes under the category of neutral to alkaline range under different water sampling conditions in which they are taken. In different blocks of Pratapgarh few locations in Babaganj Block recorded highest pH value and lowest pH value is recorded in Kunda Block. pH of drinking water is normally between 6.5 to 8.5 according to the WHO(2011) and BIS(2012) drinking water quality Standards. Poreydhana in Mangraura block exceeds the maximum limit of 8.5 as per WHO(2011) and BIS(2012) drinking water Standards.

The observed Dissolve Oxygen Content in the study area, overall DO values ranging between 2.1 to 4.1 (Table II) in different water sampling condition in which they are taken. The highest value of DO is recorded in Patti block and lowest value of DO is recorded in Kunda Block. This comes within the safe range >5 mg/L, given in WHO (2011) drinking water quality Standards.

In the study area the observed overall Turbidity values ranging between 2 to 23 (Table II) in different water sampling condition, in which they are taken, the highest value of turbidity are recorded in Shivgarh block and lowest of turbidity is recorded in Kunda Block. The drinking water is normally 5 NTU according to the WHO (2011) and BIS (2012) drinking water quality Standards. There was a place of Bhagvatganj in Shivgarh block exceeds the maximum turbidity level of 5 NTU given in WHO(2011) and BIS (2012) drinking water quality Standards.

In the study area the observed overall total Phosphorus values ranging between1.13 to 1.43 mg/Lin different water sampling condition (Table II) in which they are taken. The highest value of total Phosphorus are recorded in Lalganj block and lowest value of total Phosphorus is recorded in Kunda block.

NO_3 is a naturally occurring form of nitrogen found in soil. Nitrogen is essential to all life. Most crop plants require large quantities to sustain high yields. The formation of nitrates is an integral part of the nitrogen cycle in our environment. In moderate amounts, nitrate is a harmless constituent of food and

Table 3: Water quality parameters of different blocks of district Pratapgarh of Uttar Pradesh

S.No.	Blocks		pH	DO mg/L	BOD mg/L	Turb. NTU	PO_4 mg/L	NO_3 mg/L	F. Coliform/ 100 ml	WQI	SO_4 mg/L	Cl mg/L	F mg/L	Fe mg/L	Alkalinity mg/L	T.D.S. mg/L	T.H. mg/L
1.	**Aashpur**	Mean	7.820	2.980	1.390	3.167	1.250	0.694	375.340	43.770	14.080	75.000	0.610	0.230	86.670	564.200	242.000
	devosara	S.d.	0.397	0.643	0.504	1.019	0.094	0.570	54.620	1.958	7.450	25.970	1.110	0.145	26.180	91.460	54.420
	n=30	Range	7.1-8.5	2.1-4.1	0.76-2.5	2.0-5.0	1.13-1.43	0-2.215	275-455	39.38-46.86	0-28.8	40 -120	0.2-6.4	0-0.5	40-140	406-750	190-350
2.	**Sangramgarh**	Mean	7.824	3.034	1.374	3.345	1.249	0.596	372.069	44.008	6.290	91.724	0.369	0.245	118.621	543.793	236.552
	n=29	S.d.	0.481	0.674	0.485	1.143	0.095	0.415	55.429	1.579	8.225	32.631	0.195	0.174	28.998	62.359	75.275
		Range	7-8.5	2.1-4.1	0.76-2.5	2.0-5.0	1.13-1.43	0-1.772	275-455	39.52-46.49	0-28.8	30-140	0-0.6	0-0.5	60-160	400-640	0-340
3.	**Babaganj**	Mean	8.014	3.071	1.307	3.143	1.217	0.443	360.000	44.780	12.343	84.286	0.343	0.129	82.857	540.000	232.857
	n=7	S.d.	0.471	0.780	0.241	0.690	0.065	0.362	60.484	1.389	7.257	37.796	0.127	0.138	20.587	46.547	45.722
		Range	7.3-8.5	2.1-4.1	0.8-1.5	2.0-4.0	1.14-1.34	0-0.886	275-455	42.83-46.66	0-19.2	20-130	0.2-0.6	0-0.4	60-110	480-620	180-310
4.	**Vihar**	Mean	7.728	3.050	1.436	3.156	1.246	0.872	372.031	43.236	11.100	111.563	0.545	0.259	103.438	438.250	237.188
	n=32	S.d.	0.492	0.670	0.531	1.110	0.091	0.579	57.458	1.705	7.753	43.708	0.721	0.162	29.796	146.221	38.541
		Range	7-8.5	2.1-4.2	0.76-2.5	2.0-5.0	1.13-1.43	0-2.215	275-455	39.39-45.83	0-28.8	40-200	0.2-4.4	0-0.5	60-160	4-620	190-310
5.	**Gaura**	Mean	7.910	3.003	1.421	3.552	1.250	0.854	372.586	43.366	13.903	108.966	0.464	0.314	121.034	564.138	253.103
	n=29	S.d.	0.465	0.648	0.524	1.617	0.094	0.797	55.816	2.311	10.760	39.672	0.143	0.175	78.801	66.682	71.967
		Range	7.2-8.5	2.1-4.1	0.76-2.5	2-9.0	1.13-1.43	0-3.5	275-455	38.33-46.56	0-48	40-200	0.1-0.75	0-0.8	40-500	480-720	160-520
6.	**Belkharnath**	Mean	7.803	2.980	1.374	2.900	1.248	0.664	371.167	43.989	11.840	90.167	0.447	0.283	95.000	599.667	239.000
	n=30	S.d.	0.423	0.655	0.477	0.995	0.093	0.415	58.585	1.485	6.988	45.797	0.128	0.345	40.151	290.724	72.652
		Range	7.1-8.5	2.1-4.1	076-2.5	2.0-5	1.13-1.43	0-1.772	275-455	40.67-46.04	0-19.2	20-240	0.2-0.6	0-2	60-240	450-2100	190-580
7.	**Shivgarh**	Mean	7.775	3.093	1.451	3.571	1.249	0.554	371.964	44.069	11.329	70.000	0.286	0.168	67.500	514.643	206.071
	n=28	S.d.	0.237	0.688	0.565	3.872	0.096	0.492	55.350	1.994	6.956	9.027	0.085	0.094	7.005	30.850	15.715
		Range	7.4-8.2	2.1-4.2	0.76-2.5	2.0-23	1.13-1.43	0-1.773	275-455	39.86-47.84	0-19.6	60-80	0.2-0.4	0-0.4	60-80	450-580	180-230
8.	**Sandwachandika**	Mean	7.753	2.987	1.376	2.807	1.248	0.620	375.333	43.997	10.573	77.333	0.313	0.157	75.000	544.667	225.000
	n=30	S.d.	0.245	0.644	0.505	0.978	0.093	0.429	54.614	1.571	6.853	25.180	0.104	0.117	14.324	46.589	29.449
		Range	7.4-8.5	2.1-4.1	0.76-2.5	0.2-5	1.13-1.43	0-1.772	275-455	40.09-46.8	0-19.6	40-180	0.2-0.5	0-0.4	60-120	480-700	200-350
9.	**Laxmanpur**	Mean	7.719	3.024	1.437	3.143	1.236	0.633	370.952	43.985	12.819	84.286	0.395	0.210	107.143	521.905	239.524
	n= 21	S.d.	0.409	0.691	0.532	1.108	0.084	0.385	59.825	1.479	5.566	24.202	0.150	0.126	53.023	81.769	27.835
		Range	7-8.5	2.1-4.1	0.76-2.5	2.0-5.0	1.13-1.43	0-1.772	275-455	40.17-46.14	0-19.6	40-140	0.2-0.8	0-0.4	60-270	240-680	190-290
10.	**Mandhata**	Mean	7.690	2.980	1.379	3.233	1.248	0.546	371.500	44.221	1.280	97.000	0.360	0.250	117.667	536.333	226.333
	n=30	S.d.	0.516	0.655	0.473	1.223	0.093	0.322	55.167	1.389	4.168	37.153	0.189	0.170	49.178	85.560	51.960
		Range	7-8.5	2.1-4.1	0.76-2.5	2.0-5	1.13-1.43	0-0.886	275-455	41.34-46.68	0-19.2	40-220	0-0.6	0-0.5	60-270	450-740	0-280
11.	**Kalakankar**	Mean	4.109	1.848	0.939	2.289	0.667	0.562	214.014	43.920	8.877	60.573	0.354	0.195	66.149	315.818	141.058
	n=33	S.d.	3.792	1.204	0.472	1.138	0.592	0.160	161.399	1.765	3.413	31.652	0.253	0.069	37.668	234.429	96.566
		Range	7-8.5	2.1-4.2	0.76-2.5	2.0-5	1.13-1.43	0-2.215	275-455	37.61-46.89	0-48	40-190	0-0.75	0-0.5	60-270	320-640	0-340
12.	**Sangipur**	Mean	4.109	1.848	0.939	2.289	0.667	0.562	214.014	43.908	8.877	60.573	0.354	0.195	66.149	315.818	141.058
	n=33	S.d.	3.696	1.173	0.460	1.110	0.577	0.155	157.313	1.525	3.326	30.850	0.246	0.068	36.714	228.493	94.121
		Range	7.1-8.5	2.1-4.1	0.76-2.5	2.0-5	1.13-1.43	0-0.886	275-455	40.45-46.92	0-48	30-140	0.2-06	0-0.5	60-460	450-700	180-340

13.	**Sadar n=25**	Mean	3.832	1.694	0.874	2.173	0.625	27.600	198.650	34.028	7.958	55.067	0.294	0.182	62.488	301.430	127.644
		S.d.	3.318	1.072	0.430	1.068	0.519	11.623	142.632	2.629	3.638	28.942	0.163	0.080	34.014	207.502	86.746
		Range	7-8.4	2.1-4.1	0.76-2.5	0.71-5	1.13-1.43	0-46	275-455	31.27-31.27	0-19.2	40-90	0.2-0.4	0-0.3	60-90	180-600	20-250
14.	**Kunda n=28**	Mean	3.805	1.661	0.851	2.114	0.620	0.497	195.702	44.094	7.730	53.692	0.287	0.177	60.990	296.486	125.492
		S.d.	3.130	1.021	0.418	1.039	0.490	0.194	135.087	1.806	3.570	27.937	0.156	0.079	32.727	196.818	82.322
		Range	7-8.5	2.1-4.1	0.76-2.5	2.0-5.0	1.13-1.43	0-2.215	275-455	38.84-46.84	0-28.8	40-180	0.1-1.25	0-0.6	60-460	200-720	100-340
15.	**Mangraura n=71**	Mean	7.834	3.000	1.405	3.359	1.249	0.803	371.620	43.480	11.906	111.549	0.412	0.241	111.831	560.986	239.577
		S.d.	0.510	0.648	0.511	1.190	0.094	0.552	55.083	1.809	8.465	119.805	0.168	0.155	60.670	234.003	46.520
		Range	7-9.3	2.1-4.1	0.76-2.5	2.0-5	1.13-1.43	0-2.215	275-455	39.28-46.28	0-28.8	30-1050	0-0.75	0-0.6	60-520	230-2400	130-400
16.	**Lalganj n=32**	Mean	7.753	2.969	1.383	3.156	1.259	0.540	374.375	44.197	0.900	122.500	0.250	0.219	114.063	553.438	239.688
		S.d.	0.491	0.639	0.486	1.139	0.100	0.417	54.636	1.653	3.745	44.286	0.155	0.169	36.708	69.913	56.023
		Range	7- 8.5	2.1-4.1	0.76-2.5	2.0-5.0	1.13-1.43	0-1.772	275-455	40.87-46.87	0-19.2	40-200	0-0.6	0-0.5	60-200	440-690	0-320
17.	**Patti n=27**	Mean	7.693	3.096	1.440	2.963	1.231	0.722	372.778	43.821	13.444	79.815	0.398	0.215	102.222	535.556	241.111
		S.d.	0.525	0.701	0.530	1.055	0.081	0.604	56.233	1.986	7.978	46.709	0.119	0.143	33.665	146.716	39.158
		Range	7-8.5	2.1-4.2	0.76-2.5	2.0-5.0	1.13-1.43	0-2.215	275-455	38.41-45.93	0-28.8	20-200	0.25-0.6	0-0.5	40-160	260-740	190-320
Water quality standard for drinking.	**WHO(2011)**	**6.5-8.5**	**-**	**-**	**5 NTU**	**-**	**10 mg/L**	**10 MPN/ 100 mL**	**-**	**400 mg/L**	**250 mg/L**	**1.5 mg/L**	**0.3 mg/L**	**-**	**1000 mg/L**	**500 Mg/L**	
	BIS(2012)	**6.5-8.5**	**-**	**-**	**5 NTU**	**-**	**45 mg/L**	**10 MPN/ 100 mL**	**-**	**200 mg/L**	**250 mg/L**	**1 mg/L**	**0.3 mg/L**	**200**	**500 mg/L**	**300 mg/L**	

water. Plants use nitrates from the soil to satisfy nutrient requirements and may accumulate nitrate in their leaves and stems. Due to its high mobility, nitrate also can leach into groundwater. If people or animals drink water high in nitrate, it may cause methemoglobinemia, an illness found especially in infants. The stomach acid of an infant is not as strong as in older children and adults. In the study area the observed overall Nitrates values ranging between 0 to 46 mg/L. (Table II) in different water sampling condition, in which they are taken, the highest value of Nitrates are recorded in Sadar block and lowest value of Nitrate is recorded in Babaganj block. Patarkauli in Sadar block exceeds the maximum limit of 45mg/Lgiven as per BIS(2012) drinking water Standards. The high NO_3 content in Sadar block can be due to excessive N-ous fertilizer application in the intensive cropping system (>250%) and higher net irrigated area. Nitrate levels in Sadar block are generally more than 10 mg L^{-1}, in small pockets otherwise ground water exploration data indicates in major part of the district sample are often higher than from permissible limit.

Sulfates occur naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4{\cdot}7H_2O$) and gypsum ($CaSO_4{\cdot}2H_2O$) (Greenwood & Earnshaw, 1984). These dissolved minerals contribute to the mineral content of many drinking-waters. Ingestion of 8 g of sodium sulfate and 7 g of magnesium sulfate caused catharsis in adult males (Cocchetto & Levy, 1981; Morris & Levy, 1983). From the present study it is evident that water samples contained sulphate ranged between 0 to 48 mg/L. in different water sampling condition, in which they are taken. When sulphate >0.5 mg/Lalgal growth will not occure in other hand sulphate is major contaminant in water. The highest value of sulphate is recorded in Aashpurdevosara block and lowest value of sulphate is recorded in Lalganj block. The overall observed average values of Sulphates are within the range of WHO(2011) and BIS(2012) drinking water quality Standards. Higher concentration may be attributed to weathering of sulphide minerals or anthropogenic sources like industrial and agricultural effluents (Berner and Berner, 1987). The WHO(2011) and BIS(2012) drinking water quality standards for sulphate is 400 and 200 mg/L.

Chloride is present in all natural waters, mostly at low concentrations. It is highly soluble in water and moves freely with water through soil and rock. In ground water the chloride content is mostly below 250 mg/Lexcept in cases where inland salinity is prevalent and in coastal areas.BIS(2012) have recommended a desirable limit of 250 mg/Lof chloride in drinking water; this concentration limit can be extended to 1000 mg/Lof chloride in case no alternative source of water with desirable concentration is available. However ground water having concentration of chloride more than 1000 mg /l are not suitable for drinking purposes. The samples of the present study having Chloride in range, 20 to 1050 mg/L(Table II), In different water sampling condition, in which they are taken. The highest values of Chlorine are recorded in Lalganj block and lowest value of Chlorine was recorded in Kunda block. Lala in Mangraura block exceeds the maximum chloride level of 250 given in WHO(2011) and BIS(2012) drinking water Standards. Chloride is found in ground water through the weathering and leaching of sedimentary rocks and soils and the dissolution of salt deposits. Soil porosity and permeability also play an important role in building up the chloride value, increase of chloride level in water is injurious to people suffering due to heart and kidney diseases.

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many type of rock. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Presence of other ions, particularly bicarbonate and calcium ions also affects the concentration of fluoride in ground water. The fluoride in water samples of the present study ranged between 0 to 6.4 mg/L.(Table II) the highest value of fluoride are recorded in Aashpurdevosara block and lowest value of fluoride is recorded in Lalganj block. Puredalpatsah in Aashpurdevosara block and Umarapatti in Vihar Block (Table 15) in which Flouride exceeds the maximum fluoride level of 1.5 mg/Lgiven for WHO(2011) and 1 mg/Lfor BIS(2012) drinking water Standards. The high fluoride contamination (>1.5 mg L^{-1}) two samples may be due to the dissolution of micaceous content in the alluvium. Again it is evident from the chemical analysis of the ground water samples that the he pH value of ground water in the affected area varies from 7.0 to 9.3, indicating a saline condition which favours the solubility of fluorine- bearing minerals. In acidic medium (acidic pH), fluoride is adsorbed in clay; however, in alkaline medium, it is desorbed, and thus alkaline pH is more favourable for fluoride dissolution activity. Fluoride has a unique chemical behaviour towards most of the anions and can be easily replaced even under normal temperature and pressure conditions.

Iron dissolved in groundwater is in the reduced iron II form. This form is soluble and normally does not causes any Problem by itself. Iron II is oxidised to iron III on contact with oxygen in the air or by the action of iron related bacteria. Iron III forms insoluble hydrpxides in water. The samples of the present study having Iron in range, 0 to 2 mg/L(Table II), in different water sampling condition, in which they are taken, The highest value of iron are recorded in Gaura block and lowest value of iron is recorded in Babaganj block. Padarijabar in Belkharnath block , exceeds the maximum permissible level of iron as recommended by WHO(2011) and BIS(2012) drinking water Standards. This higher value may be due to dissolution of ferrous borehole and hand pump components. Iron-bearing groundwater is often noticeably orange in colour, causing discoloration of laundry and has an unpleasant taste, which is apparent in drinking and food preparation.

In the study area the observed overall Alkalinity value ranging between 40 to 520 mg/L(Table II). In different water sampling condition, in which they are taken, the highest value of alkalinity is recorded in Gaura block and lowest value of alkalinity is recorded in Kunda block. Alkalinity exceeds the maximum permissible level of 200 mg/Lgiven in the BIS(2012) drinking water Standards in 2% of the samples in the study area. The alkalinity in the water samples may come from $CaCO_3$ being leached from rocks and soil accelerated by mining and development activities.

The TDS in water samples of the present study are in the ranges between 200 to 2400 mg/L(Table II). Based on Freeze and Cherry (1979) classification, 99% of the groundwater samples of the study area are categorized as fresh water (TDS<1,000 mg L^{-1}).The highest value of TDS are recorded in Belkharnath block and lowest value of TDS is recorded in Kunda block. Padarijabar in Belkharnath block and Lala in Mangraura exceed the maximum allowable level of 1000 mg/Lgiven for WHO(2011) and 500 mg/Lfor BIS(2012) drinking water Standards.

When water passes through or over deposits such as limestone, the levels of Ca^{2+}, Mg^{2+}, and HCO_3^- ions present in the water can greatly increase and cause the water to be classified as hard water. In the study area the observed overall total hardness value ranged between 0 to 580 mg/L(Table II) in different water sampling condition, in which they are taken. The highest value of Total hardness is recorded in Gaura block and lowest value of Total hardness is recorded in Kunda block. Narsinghpur in Belkharnath block exceeds maximum permissible level of total hardness 500 mg/Lgiven for WHO(2011) and 300 mg/Lfor BIS(2012) drinking water Standards.

WQI generally summarise the information from multiple water quality parameters into a single value. The single value in term can be used to many are data from several blocks of Pratapgarh district.WQI value is estimated using Q value and weighing factor. Most of the water samples are fall under bad water quality rating indicating impairment of water quality and progress of water quality management produce. Basically this index was developed with an aim for simple, concise and valid mode for expressing the significance of regularly generated laboratory data which is helpful to identify water quality trend and problem areas.

CONCLUSIONS

From the above study it is clear that the quality and distribution of the ground water in different regions of Pratapgarh district of Uttar Pradesh. Further, the above hydro-chemical study reveals that most of the samples have good water quality parameters suitable for drinking, agriculture and industrial purpose due to the good hydro – ecological and hydrological system and the local geology is considered to be positive in the environment. Quality assessment for irrigation suitability shows that the groundwater of the area belongs to bad category which restricts the suitability of groundwater for agricultural purposes and demands special management plan for the area. These places require treatment before its utilization. Suitable water treatment process such as water softening, ion exchange, demineralization and defluoridation should be applied to reduce the concentration of contaminants. In majority of the samples, the analyzed parameters evaluated in isolation are well within the prescribed limits and water is potable for drinking purposes.

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