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Physico-Chemical Assessment of Groundwater in Meerut City, Uttar Pradesh, India

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Abstract—*The piece of investigation was carried out to study the ground water as quality, nutrient status and physico-chemical characteristic of Meerut district of Uttar Pradesh, India. Groundwater samples collected from residential area in 5 different locations were analyzed according to standard methods. The physico-chemical parameters such as pH, DO, BOD, COD, TDS, alkalinity, calcium hardness, magnesium hardness, total hardness, nitrate, fluoride, iron and chloride have been analyzed. The results revealed that among the residential locations, many of the estimated physico-chemical parameters of residential areas are more or less within the permissible limits of WHO.*

Keywords*: Physico-Chemical Characteristics; Industrialization; Water Quality; Meerut*

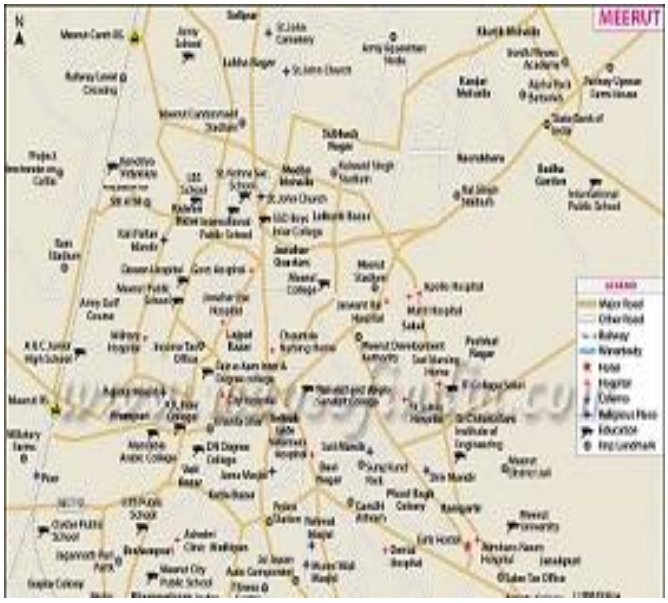
1. INTRODUCTION

The rapid rate of industrialization and urbanization in India has changed the face of urban landscape and brought in its wake problems of ground water contamination imperiling human beings. Effluents released from various industries are dumped into open pits or unlined channels without any treatment which contaminate ground water sources[1]. In urban societies like our India with developing economics, the optimum development, efficient utilization and effective management of their water resources should be the dominant strategy for economic growth, However in recent year's unscientific management and use of this resources for various purpose almost invariably has created undesirable problems in its wake, water logging and salinity in the case of agriculture use and environment pollution of various limits as a result of mining, industries and municipal use. The ground water, the main source of drinking water has become a cocktail of chemicals and human wastes in most of the Indian cities[2]. It has been observed that among the population belongs to urban societies, about 10% of people are not able to have safe drinking water apart from that 30% of urban and 90% of rural households depend on unsafe water sources to meet their daily needs [3, 4]. Contaminated water containing virus causes various diseases. In India about 21% of communicable diseases are water borne [5].

Water is one of the most indispensable resources and is the elixir of life. Water constitutes about 70% of the body weight of almost all living organism. Life is not possible on this planet without water. It exists in three states namely solid, liquid and gas. It acts as a media for both chemical and biochemical reactions and also as internal and external medium for several organisms. 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 [6].

1.1 Geographical location of Experimental Site:

Meerut city (29°41` North latitude and 77°43` East longitude, Fig. 1.1) was chosen as the study area because it is the second largest urban centre in National Capital Region experiencing rapid urbanization and is the second most important small scale industrial centre in the state of Uttar Pradesh. Density of population is very high in the core areas of the city. The density of population is 4,781 persons/ km^2. It has experienced a continuous increase in the population of the city from 0.29 million in 1961 to 1.4 million in 2011[7, 8]. The population growth registered an increase of 15.92% during the decade 2001-11, which could be attributed to high industrial growth during the same decade [8,9]. The topography of the city is featureless plain with many small and big drainage canals. Maximum and minimum temperatures remain 44^0C during summer and 2^0C during winter. The average rainfall of the city is 714 mm.Meerut district is amongst top 100 districts in India having more than 4500 small scale industrial units. In fact Meerut considered as first District in Uttar Pradesh and 39 in all India with about 8,244 small scale units [10]. These industries are operating in old part of the city while large industries have grown in newly developed areas. However, due to absence of any zoning regulation by authorities or a proper plan for urban environment, most of the industries in the city located haphazardly and were responsible for unhealthy living conditions [11].



Source: Google map of meerut city in India

Fig. 1.1: Map of Meerut City

As a result of industrialization, large cluster of migrants entered into the city for their employment purpose and thereby demand for residential areas created. These migrants occupied vacant government lands and developed squatter settlements. Among the total population of the city, about 30% persons live in slums having unhealthy and poor conditions [12]. There are more than 102 notified slums in Meerut city. Among these, 51% have access to municipal water supply and only 7.0% have partial water supply [13]. There are only 30% area of the city is covered through sewerage system while in remaining parts of the city, people are using septic tanks and soak pits. The major source of drinking water within the Meerut Municipal Corporation depends upon tube well. It is estimated that about 46,000 tube wells are privately owned and 500 are installed by the government. Among the 78 wards, 59 are provided with adequate municipal supply and remaining 19 wards having no systematic water supply [14]. Meerut city placed on the banks of river Ganga, once boasted of a large number of irrigation canal however due to increase in uncontrolled population and industrialization the city is witnessing water crisis. The increasing demand for water in the city raised demand for several new installations of tube wells which in turn resulted in fast lowering of the groundwater table. It is estimated, the water table has now fallen down up to 20 meters Unlike four decades ago when water came brimming even in a pit just 2-3 meters deep [15].

2. MATERIALS AND METHODS:

Fifteen ground water samples from both the hand pumps and municipal water during April 2015 were collected. Sampling locations were selected on the basis of the presence of residential areas and colonies. Five wards (**Transport nagar, Maliyana, Jain nagar, Brahmapuri and Beri pura)** having concentration of large and small scale residential were selected. From each selected ward 3 water samples from hand pump and Tube well water in 2015 were selected from each selected location. Samples were collected in sterilized plastic/polyethylene bottles during pre-monsoon season. Before sampling, all the sampling bottles were washed and rinsed thoroughly with the groundwater to be taken for analysis. The samples were tested for nineteen physical and chemical parameters using standard methods [16].In present study the methods used in testing of groundwater is already discussed in Table no.1.

3. WATER ANALYSIS

In present study ground water sample were collected and analyzed for various physiochemical parameters to find out the characteristics of the ground water of Meerut City, India. All the samples were analyzed to determine pH, DO, COD,BOD, TDS, Alkalinity, Calcium Hardness, Magnesium Hardness, Total Hardness, Nitrate, Fluoride, Iron and Chloride using standard methods[17].

4. RESULT AND DISCUSSIONS

The physicochemical analysis of the ground water and the result comparison with the Indian Standards and WHO are summarized in table 2.

S. No	Parameter	Methods
1	pH	pH meter
2	Flouride	Ion Analyzer Method
3	Total Hardness	EDTA titration
4	Alkalinity	Indicator method
5	TDS	Gravitimetric method
6	Chloride	Silver nitrate method
7	Phosphate	Ammonium molybdate blue method
8	Dissolved oxygen	Winkler's method
9	BOD	Wrinkler's method
10	COD	Open reflux method
11	Sulphate	Turbidimetric Method
12	Nitrate	Ion Analzer Method
13	Heavy metals (Mn,Zn,and Fe)	Atomic Absorption Spectrophotometer

pH: Alkalinity of water measure by pH. The pH values of residential area are within the permissible limits of WHO standards (7.0–8.5). The value of pH found 7.12 – 8.02. This may be caused due to different types of buffers normally present in the ground water [18]. The results revealed small variations in pH. The mild alkalinity represents the presence of weak basic salts in the soil [19]. The mild alkaline nature confirms that approximately 95% of CO2 in water is available as bicarbonate [20]. pH is considered as an important ecological factor and provides an significant piece factor and piece of information in several type of geochemical equilibrium or solubility calculation.

Table 1: Methods used in testing of water sample.

Parameters	Indian Standard	WHO Standard
pH	6.5-8.5	7.0-8.0
Total hardnes,mg/l	300	100
Calcium, mg/l	75	75
Magnesium, mg/l	30	30
Chloride, mg/l	250	250
Total dissolved solids, mg/l	500	1000
Iron, mg/l	0.3	0.1
Fluoride, mg/l	0.1	0.1
Nitrate, mg/l	45	50
Sulphate, mg/l	200	250
Sodium, mg/ l	----	200
Potassium, mg/l	---	---
Alkalinity, mg/l	200	---

Table 2: Comparison of Ground water quality with drinking water standards, Indian and WHO

Manganese, mg/l	30	0.05
Zinc, mg/l	5	5

Alkalinity: The ranges of alkalinity have been found in between 45.9-48.8 mg/l in study area of Meerut. In residential area of Meerut it has been found 45.9-48.8 mg/l, which is also shown in table 3.

T.D.S: The total dissolved solids (TDS) values of sampling area are less within the permissible limits of WHO (500 ppm). High levels of TDS may aesthetically be unsatisfactory for bathing and washing. The table 2 shows that the residential area TDS values are between 368.8-394.3 mg/l.

Dissolve Oxygen: The condition in case of dissolved oxygen (DO) is slightly complicated since in contrast to other pollutants, the quality of water is enhanced if it contains more oxygen. An ideal DO value of 5.0 mg/l is the standard for drinking water [13]. In natural waters, DO values are varying according to the physicochemical and biological activities. In residential area it has been found between the ranges of 4.20-4.83 mg/l

Calcium Hardness: Calcium is from natural sources like granitic terrain which contain large concentration of this element. The result shows that calcium values for most samples in residential area are lie within the level of WHO. High values of calcium hardness in study area may be due to the cationic exchange with sodium. However, low values do not mean that it is not influenced by the pollutants but it might be due to the reverse cationic exchange with sodium. (i.e.) sodium ions replace Ca ions thereby reducing their concentration in ground water after percolation. In the study, values of calcium hardness are within the permissible level of WHO. The ranges of calcium hardness have been found in between 69.2-93.3 mg/l in residential area of Meerut.

Characteristics of Ground water: The characteristic of ground water of study area are as under:-

Table 3: Characteristics of Ground water.

Sample no.	pH	TH	Ca	Mg	Cl	TDS	Fe	F	NO3	SO4	Na	K	Alkalinity	Mn	Zn	DO	TS	BOD	COD
1	7.12	105.2	69.2	15.2	122.2	370.6	0.12	0.18	12.2	18.2	88.3	17.2	46.8	0.01	2.34	4.20	189.2	1.90	7.21
2	7.23	111.4	91.6	16.7	121.7	368.8	0.21	0.17	13.1	19.1	88.9	18.1	47.4	0.02	2.35	4.46	188.7	2.10	7.23
3	7.29	107.2	89.2	16.2	123.2	369.2	0.19	0.16	12.8	19.6	90.2	17.6	47.2	0.01	2.47	4.57	192.4	2.01	7.15
4	7.32	98.3	74.8	17.3	123.5	373.8	0.16	0.09	15.3	17.8	86.5	17.8	46.5	0.03	2.52	4.61	203.6	1.95	7.20
5	7.59	102.5	83.6	18.1	125.2	372.5	0.18	0.10	16.5	18.3	87.3	18.3	45.9	0.04	2.56	4.67	202.2	1.90	7.18
6	7.84	101.8	76.5	14.8	122.8	374.1	0.23	0.11	17.2	18.8	87.9	18.8	46.9	0.02	2.59	4.64	203.7	1.86	7.22
7	7.88	106.2	71.7	17.6	126.5	380.2	0.24	0.07	14.4	16.8	90.2	16.8	48.3	0.04	2.78	4.56	198.3	1.89	7.24
8	8.02	108.4	68.6	16.9	127.1	382.3	0.26	0.06	15.3	17.7	91.4	17.7	48.8	0.04	2.71	4.62	198.4	1.91	7.34
9	7.98	107.7	66.8	15.2	127.5	382.9	0.28	0.09	16.4	17.2	92.1	17.2	47.6	0.05	2.79	4.67	199.3	1.79	7.39
10	7.43	104.5	85.3	16.6	123.7	389.2	0.24	0.12	17.1	21.3	87.6	16.3	47.2	0.03	2.21	4.78	190.4	1.82	7.35
11	7.35	110.6	90.2	15.9	122.8	392.4	0.28	0.11	17.5	22.1	88.4	17.1	47.9	0.04	2.32	4.81	191.7	1.89	7.51
12	7.52	103.9	83.2	17.7	123.3	392.7	0.27	0.12	18.3	21.9	88.9	16.9	48.3	0.03	2.24	4.83	192.7	2.01	7.47
13	7.26	99.7	78.7	18.3	124.2	390.2	0.22	0.13	16.8	18.6	86.3	18.6	46.8	0.04	2.76	4.76	188.6	2.11	7.24
14	7.37	107.8	89.9	18.6	125.1	394.3	0.24	0.14	17.6	19.3	87.4	19.3	46.2	0.05	2.81	4.71	189.6	1.98	7.28
15	7.28	112.5	93.3	17.7	124.8	393.9	0.23	0.12	18.4	19.7	86.9	19.7	45.9	0.04	2.85	4.79	188.7	1.92	7.34

Total Hardness: Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water [15]. The Total Hardness is an important parameter of water quality whether it is to be used for domestic, industrial or agricultural purposes. It is due to the presence of excess of Ca, Mg and Fe salts. The carbonate and bicarbonate concentrations are useful to determine the temporary hardness and alkalinity. The alkalinity is mainly due to bicarbonates. The maximum total hardness value was observed as 112.5 mg/l at residential area.

Nitrates: The high nitrogen content is an indicator of organic pollution. It results from the added nitrogenous fertilizers, decay of dead plants and animals, animal urines etc. They are all oxidized to nitrate by natural process and hence nitrogen is present in the form of nitrate. The increase in one or all the above factors is responsible for the increase of nitrate content [16]. The ground water contamination is due to the leaching of nitrate present on the surface with percolating water. The nitrate content of mining and residential is well within the

permissible limit of WHO. The low nitrate content may be due to the less usage of nitrogen fertilizers and less disposal of wastes around study areas. The concentration varies from 12.2-18.4mg/l.

Fluoride: Fluoride occurs as fluorspar (fluorite), rock phosphate, triphite, phosphorite crystals etc. in nature. Among factors which control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock mineral assemblage through which the ground water is circulating. In this study, the fluoride concentration of all the sampling areas lies within the range of the permissible limit of WHO. The source of fluoride in these water samples may be weathering of rocks, phosphatic fertilizers used for agriculture or the sewage sludge. The percolation of phosphatic fertilizers from the agricultural runoff from the nearby lands and discharge of domestic wastes or the wastes from the surrounding industries increases the fluoride values. This study shows the all values are within the permissible level of WHO the concentration found during study period are between 0.06-0.18 mg/l.

Iron: The main sources of iron in ground water are naturally as a mineral from sediment and rocks or from mining, industrial waste, and corroding metal. The ranges of iron have been found in between 0.12-0.18 mg/l in residential area of Meerut which is under WHO guidelines, from the table 1 it is also shown that all sites concentration is within the permissible limits of WHO. The high concentration of iron causes a bitter astringent taste to water and a brownish color to laundered clothing and plumbing fixtures.

Chloride: Chloride occurs naturally in all types of water. Chloride in natural water results from agricultural activities, industries and chloride rich rocks. High concentration of chloride is due to the invasion of domestic wastes and disposals by human activities. In the study areas chloride level is within the permissible limit of WHO, which indicates less contamination of chloride. The ranges of chloride have been found in between 121.7-127.1 mg/l in residential area of meerut.

5. COCLUSION

The water quality parameters ware evaluated to assess the quality of ground water. The interpretation of physico-chemical analysis reveals that the groundwater in Meerut City is fresh to brackish and alkaline in nature, which is good for drinking and agricultural purpose. The major cations (Ca and Mg) and major anions (Chloride, Bicarbonates, Sulphate and Nitrates) of the study area are well within the permissible limits for the entire area. In major places, total hardness is generally within the limits in the groundwater, which makes the groundwater of the study area suitable for drinking. In general the quality of groundwater in Meerut City is good and moderate in most of the observations areas. Saline pockets are observed in certain areas like Transport Nagar and Maliyana. The main reason for the presence of larger amount of dissolved solids may be due to geological formation or seepage from fertilizers or local contamination. This may cause high salinity. Generally the pH of the water has a small variation due to buffering action of water with Carbon-di-oxide. Regarding the Meerut City groundwater the pH value range lies within the permissible li mit except in few places. The Chloride concentrations in all the hand pumps and tube wells of this area are found to be within the limit. The concentrations of Nitrate in most of the samples are within the permissible limit. The concentration of Fluoride is found to be within the permissible limit in most of the areas.

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