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Assessment of Quality Characteristics of Underground Water using Water Quality Index - A Case Study of Rural Areas from Gwalior District

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Abstract: ***Groundwater is a characteristic asset for drinking water. Like other normal assets, it ought to be surveyed consistently and individuals ought to be made mindful of the nature of drinking water. The present study is gone for evaluating the water quality index (WQI) for the groundwater of Gwalior district. This has been executed by collection of groundwater samples in January and February months and subjecting the examples to a far reaching physico-chemical investigation. For ascertaining the WQI, 8 Parameters have been viewed which are; pH, electrical conductivity, alkalinity, Acidity, total hardness, chloride, total dissolved solids, total suspended solids. The result shows that the water quality index of the current study fall in poor category for these water samples and ranges from 43.33 to 106.58. The high value of water quality index has been observed to be primarily due to higher concentration of Total dissolved solids, hardness and Alkalinity in the underground water of the villages. In general, water in some studied areas is acceptable to a certain limits only and need to be further treated before using for drinking purpose.***

Keywords: Water; Groundwater; Quality Index; Quality Rating; Quality Parameters of Water; Contamination; water quality standards

I. INTRODUCTION

India is enriched with rich and immense diversified qualities of characteristic assets, water being one of them. Water is nature's most magnificent, inexhaustible and fundamental components for the presence of individuals, creatures and plants [1]. Water is not just vital for the lives of creatures and plants, additionally involves a one of a kind position in industries [2]. Groundwater is an essential source of water supply all through the world. The suitability and the quality of groundwater for human utilization and for watering system are dictated by its physiochemical and bacteriological properties [3]. In a few territories of the world, individuals face genuine water lacks in light of the fact that groundwater are utilized speedier than it's actually recharged [4]. The growth of population and improving living standard puts numerous and various weights on the quality and the amount of water on the entrance to ground. Water quality assessment and its evaluation is established part of water quality administration. Assessment of ground water management is to acquire data on groundwater and synthetic quality through agent inspecting [5]. Because of deficient supply of surface waters, the greater parts of population in India are depending on the groundwater assets for drinking, residential, mechanical, and watering system employments. Multitudinous towns and numerous urban communities in India get water supply from groundwater for various uses through municipal supply and extensive number of private boreholes. Around one billion individuals are specifically reliant upon groundwater in Asia alone, and In India, a large portion of the populace is depending on groundwater as the main source of drinking water supply [6]. The groundwater is accepted to be relatively much perfect and free from contamination than surface water. But, effluents discharge from industries, local sewage and waste dump causes the groundwater to get contaminated and formed health issues [7]. As of late, as a result of consistent development in populace, quick industrialization and the going with innovations including waste transfers, the rate of release of the pollutants higher than the rate of their purification. Subsequently, the qualitative analysis of water is most important to evaluate the nature of groundwater of any area that impacts the needs of domestic, industrial, and agricultural activities.

The report got on the eve of the 3rd world water forum held at Kyoto Japan march 16, 2003, by UN parented in the World Water Assessment Program me (WWAP) under UNESCO (the Hindu, may 21, 2003). The source of water decreases day by day due to unhealthy treatment of water in industries and due to change of atmospheric conditions, agriculture and commercial wastes and unexpected change in climate.

A. *Objective of the Work*

The some objectives of current study are:

1) Selection of those villages in which quality of water is not good in 4-blocks, also considering population a main concern.
2) Analyze for parameters that are most important for the calculations in WQI that best describes the groundwater health based on the desired criteria. The parameter sets selected on the basis of their importance and the effects on the human health and the ecosystem.
3) Characterize water quality on the basis of a single parameter at different-different locations.
4) Finding relationships between the Physical and chemical parameters of the underground water using statically approach.
5) Calculate WQI to access the overview of the quality of water, which will be utilized for the future development monitoring and groundwater quality changes in the research.
6) This WQI will be also used to compare the current and future impacts on the groundwater health.

B. *Study area*

Gwalior is the oldest and foremost district of the mid India. It is present in the north part of the MADHYA PRADESH state located at altitude of 196 meters above the sea level and geographically stated at 26.22 North latitude and 78.18 East longitudes. Gwalior climate is extreme both in summer and winter. During the summer season, the climate of the Gwalior city is conquered by the burning heat level which is very high from month of April to June. The maximum temperature during this season reaches to about 43-47 degree centigrade. Precipitation in GWALIOR begins in the late of the June or the early in the July months in the monsoon season and receives 880mm per annum.

The current study is based on the analysis of the groundwater superiority of the blocks of GWALIOR district. In this study some most dense and lower water quality sites are chosen within 4-BLOCKS of the Gwalior district. In each block 3-4 most dense and bad groundwater quality villages are being selected and samples were collected from these villages. The fourteen stations are pointed out in the blocks of the Gwalior district and the samples were collected through the deep bore well. The designated locations details presented in the Table 1 and marked below in the Fig.1.

Table 1 Sampling locations and sources

Title	Locations	Source of extraction	Latitude	Longitude	population
L1	BELGADA	Deep bore well	25.7682	77.9453	977
L2	SILHA	Deep bore well	25.7789	78.0395	1,131
L3	KERUA	Deep bore well	25.7348	78.1051	3,737
L4	FATEHPUR	Deep bore well	25.9120	80.7996	961
L5	KALAYANI	Deep bore well	26.0248	78.2305	3,424
L6	TAKENPUR	Deep bore well	25.9838	78.2989	12,348
L7	AKBAI BADI	Deep bore well	25.9749	78.3330	4,015
L8	DABRATOWN	Deep bore well	25.8879	78.3373	20,629
L9	NAYAGAON TANK	Deep bore well	26.1047	78.0709	415
L10	PANIHAR	Deep bore well	26.0982	78.0281	2,164
L11	SUSERA	Deep bore well	26.3239	78.1536	2,987
L12	PARSEN	Deep bore well	26.3163	78.3785	4,094
L13	JAGUPURA	Deep bore well	26.2925	78.3359	304
L14	PURANICHAVNI	Deep bore well	26.2639	78.1308	10,219

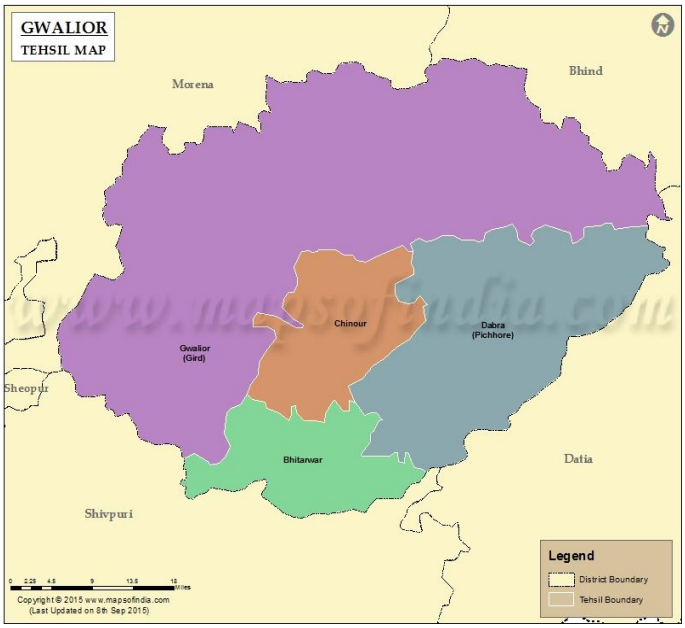
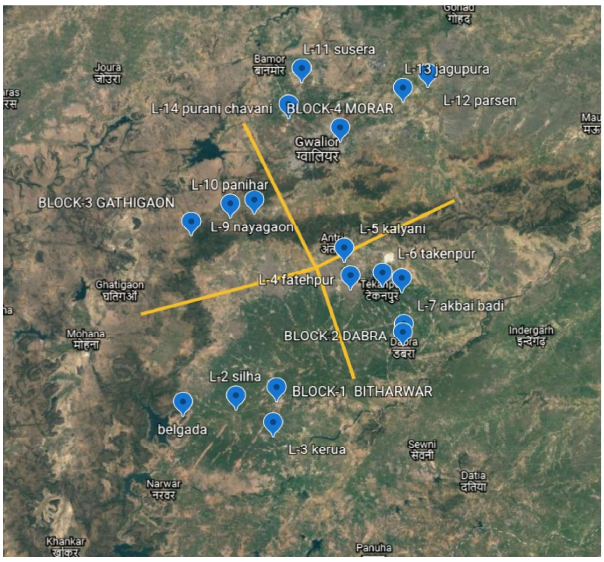


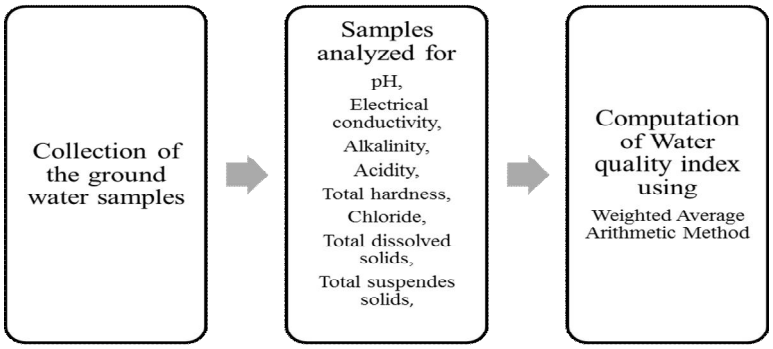
Figure 1 Sampling locations



II. MATERIALS AND METHODS

A. Methodology

The flow chart for methodology is given below.



The every sample is analysed for the given water quality parameter such as pH, electrical conductivity, alkalinity, acidity, hardness, chloride, TDS, total suspended solids.

The computation of WQI has been done by Weighted Arithmetic Index method and the outcomes were compared with drinking water norms as per WHO, BIS and ICMR. The methods and instruments which are used for calculation of water quality parameters are given below in the table 2.

Table 2 Bureau of Indian Standard (BIS) for drinking water (IS 10500: 1991)

S. No.	Parameters	Indian standards for drinking water (IS 100500; 1991)
1	pH value	8.5
2	Electrical conductivity	300 (µmhos)*
3	Alkalinity	200 (mg/l)
4	Acidity	200 (mg/l)
5	Total hardness	200 (mg/l)
6	Chloride	250 (mg/l)
7	Total dissolved solids	500 (mg/l)
8	Total suspended solids	30* (mg/l)

*Considered from Indian council of medical research (ICMR-1975)
*considered from Central Public Health and environmental engineering organization (CPHEEO)

As per standard procedures recommended by American Public Health Association (APHA) (2012), C.N. Sawyer, Central pollution control board (CPCB) laboratory manuals. The average value of three observations of each sample was taken as the final experimental value and these values are compared with standard values recommended by WHO and Indian standards for drinking purpose in Table 3.

Table 3 Methods and Instruments used for analysis

S. No	Parameters	Instruments used	Method adopted
1	pH value	Digital pH Meter (Systonic-361)	pH meter
2	Electrical conductivity	Conductivity meter (century CC-601)	Conductivity meter
3	Alkalinity	-	Neutralization by standard acid
4	Acidity	-	Neutralization by standard base
5	Total hardness	-	EDTA titration method
6	Chloride	-	Argento metric titration
7	Total dissolved solids	-	Gravimetric method
8	Total suspended solids	-	Gravimetric method

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B. Water Quality Index (WQI)

The WQI is one of the best effective tools to monitor the surface as well as groundwater pollution and can be used efficiently in the implementation of the water quality up gradation programme. The main objective of water quality index is to turn the complicated data into simple information that is comprehensible and unusable by the public [8].

In this dissertation work, the weighted average arithmetic method of WQI calculation is adopted. In this method, the calculation of WQI were done in three steps,

In the first step, the quality rating scale (Qi) for each parameter is calculated by using given equation;

$$Q_i = \frac{100\,(V_n - V_i)}{(V_s - V_i)}$$

Where,

Vn = estimated value of nth parameter of sample

Vs = recommended value of water quality parameter as per WHO or BIS

Vi = ideal value (0 for all, except pH and dissolved oxygen, it is taken 7 and 14.6 respectively)

In the **second step**, the unit weight (Wi) for each parameter is calculated by following formula;

$$Wi = \frac{k}{S_n}$$

Where,

Sn = standard recommended value of nth parameter

k = proportionality constant and can also calculated by given equation

$$k = \frac{1}{\sum S_i}$$

Where,

Si = standard value of parameter.

Finally in the **last step,** WQI were calculated by;

$$WQI = \frac{\sum Q_i W_i}{\sum W_i}$$

Where, i = no. of parameters measure

The computation of WQI is classified into five categories, mentioned in the table 4.

Table 4 WQI for ground water [7] [9]

WQI range	Water quality rating	Grading
0-25	Excellent	A
26-50	Good	B
51-75	Poor	C
76-100	Very poor	D
>100	Unsuitable for drinking	E

III. OBSERVATIONS OF RESULTS

A. Results

The fourteen different locations of the Gwalior district are considered to carry out the water samples from January (2020)-February (2020). During that period, 14 underground Water samples were collected from those points and 10 qualities parameters are examined to recognize the quality Characteristics of underground water (Table 5). There are 10 parameters are assigned to establish the Water quality Index separately for each location in the duration of study; the result shows that WQI of selected areas falls in poor category (Table 6).

Table 5 Physicochemical analyses of water samples

LOCATIONS	pH VALUE	ELECTRICAL Conductivity	ALKALINITY	ACIDITY	TOTAL HARDNESS	CHLORIDE	TOTAL DISSOLVED SOLIDS	TOTAL SUSPENDED SOLIDS
L1	7.78	1254	415	39	172	56	790	20
L2	7.85	1546	340	18	240	92	990	40
L3	7.71	938	328	39	335	167	570	20
L4	7.74	5765	390	57	410	397	3690	40
L5	8.1	891	558	21	182	36	570	20
L6	7.9	1890	476	13	111	47	1150	20
L7	7.67	2789	527	61	400	299	1690	20
L8	7.8	1585	587	40	441	195	990	30
L9	8.0	610	192	14	154	107	390	30
L10	7.64	1165	203	39	178	45	400	00
L11	7.91	703	160	28	124	36	410	20
L12	7.75	3376	662	57	460	356	2140	20
L13	7.7	547	340	28	212	30	350	00
L14	7.81	907	378	52	336	134	580	00

All the parameters in the mg/l excepting pH and electrical conductivity (µmhos)

Table 6 water quality index of study areas

Locations	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
Water quality index	66.76	61.89	63.22	106.58	80.01	76.53	80.23	84.12	74.62	43.33	63.56	92.57	44.13	55.46
Categorization	Poor	Poor	Poor	Unsuitable for drinking	Very poor	Very poor	Very poor	Very poor	Poor	Good	Poor	Very poor	Good	Poor

Table 7 A model calculation of WQI for L1

Parameters	Actual obtained value (Vn)	Recommended standard value (vs)	Unit weight (Wi)	Quality ratings (Qi)	Weighted values (Wi*Qi)
pH	7.78	8.5	0.000069675490	52	0.003623125
Electrical conductivity	1254	300	0.000001974139	418	0.00082519
Alkalinity	415	200	0.000002961208	207.5	0.000614451
Acidity	39	200	0.000002961208	19.5	0.00005774
Total Hardness	172	200	0.000002961208	86	0.000254664
chloride	56	250	0.000002368967	22.4	0.000053065
TDS	790	500	0.000001184483	158	0.000187148
TSS	20	30	0.000019741388	66.67	0.001316158
		1688.5	∑W= 0.00010382809		∑WiQi= 0.006931545
WQI = 66.75982552					

Fig. 2 pH values at different locations

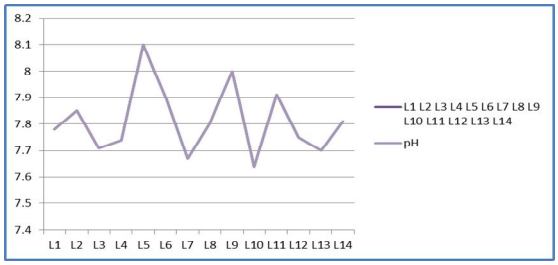


Fig. 3 electrical conductivity variation

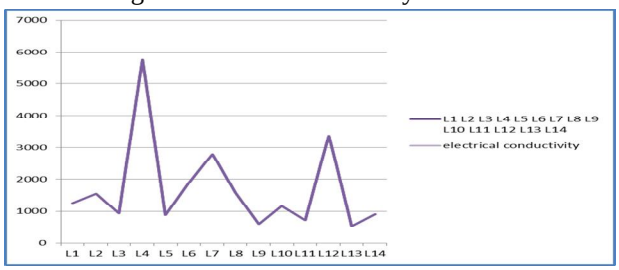


Fig. 4 Alkalinity variation

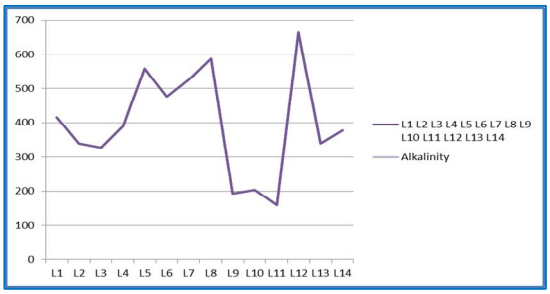


Fig. 5 Acidity variation

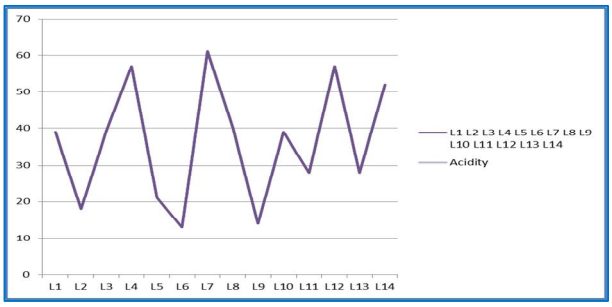


Fig. 6 Total hardness variation

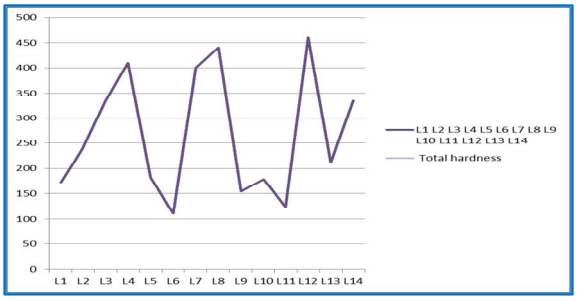


Fig. 7 Chloride variation

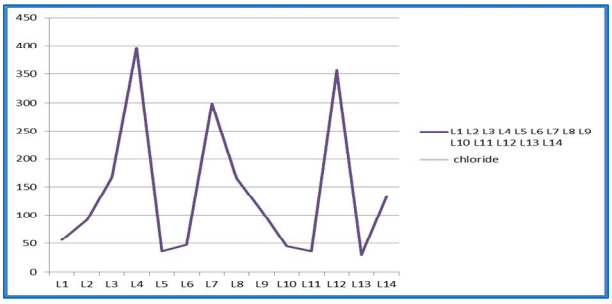


Fig. 8 Total dissolved solids variation

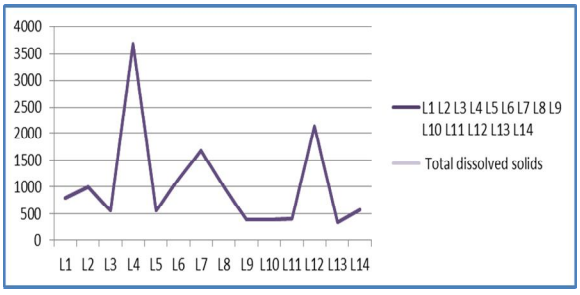


Fig. 9 Total suspended solids variation

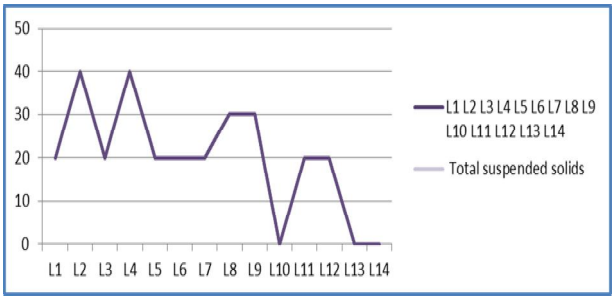
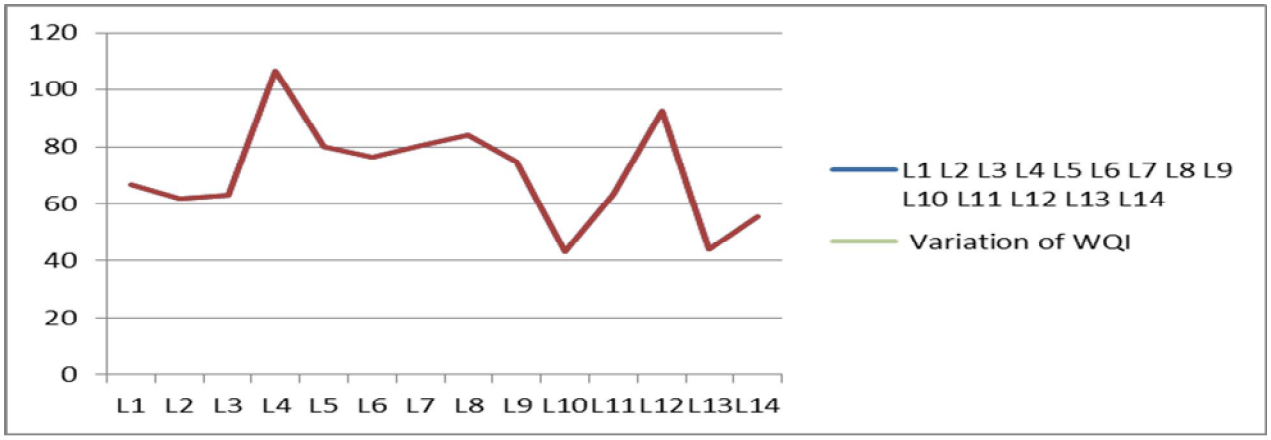


Fig.10 Water quality variation at locations



IV. CONCLUSIONS

In the present time, most of the sources of water fall down because of the short of rainfall, continuously cutting of the tree (deforestation) and most important is rapid urbanization. The speedy progress in economic development, population, human advancement applies various toxic weights on the quality of groundwater of Gwalior district. This seriously focuses on the demand of the water and the need for the treatment of water. Though, the present study focuses on underground water quality features and calculated WQI for the easy of study.

Some points have been concluded from this study mentioned below.

A. The range of WQI in mostly all locations are higher (>50) which are lies in the poor and very poor categories. Only in the two locations (L10 & L13), the water quality index is lies in Good category in block 3 and block 4 respectively.

B. In the block 1 - village FATEHPUR (L4), water quality index is very high (>100) is lying in Unsuitable for drinking category. It requires some degree of pretreatment before use.

C. In this study we have clearly observed the value of WQI for all four blocks, the water quality index of block 1 and block 2 villages lies in very higher ranges.

D. At all the locations pH, Acidity and total suspended solids values are lying within the permissible limit. Electrical conductivity, Alkalinity, Hardness and total dissolved solids are greater than desirable limits at almost all locations. Chloride concentration is within desirable limit except some locations (L4, L7, and L12).

E. The high estimate of WQI in villages has been observed because of the higher concentration of hardness, Total dissolved solids and alkalinity.

F. The higher concentration of Hardness will lead to higher soap consumption, cardiovascular diseases, and digestion problems and damages in boilers, pipes and utensils.

G. The higher concentration of total dissolved solids directly indicates that the water is having higher concentration of ions, calcium, magnesium, fluorides and chlorides which in excess may decay the teeth and skeletal damages. The TDS may affect the taste of water (bitter, salty, metallic and unpleasant), stiffness in joints, kidney stones, blockage of arteries etc. Finally, It is concluded that the underground water for these villages should be given pre-treatment (especially for L4) before utilization and supply to avoid health hazards. There are some pre-treatment units, which can be used before utilization like lime soda process, ion exchange process, zeolite process, disinfection, chlorination etc. to control the higher range of hardness and TDS.

H. Future scope of the work This study is not the end of groundwater quality characteristics pretend in the area rather it is a preliminary effort for detailed imitation in the future. With the supplementary data, the improvement of the imitation is possible, which probably the advance edition of quality characteristics of the district.

I. If in Future laboratory observations of parameters and testing techniques will improve then more effective and accurate results of groundwater will be known to us.

J. In the present study, only the fourteen most dense and having poor quality, villages of the Gwalior district are considered for evaluation and there are many part of the blocks are not mentioned and less number of parameters are measured for evaluating

the WQI. Thus in future studies, we should think about these zones and study groundwater quality conditions that will provide an additional data.

K. Once improved results of the villages will be obtained, than brief simulation should be carried out for better future predictions and treatment techniques.

L. Finally it is advised to consider these zones in future to obtain overall quality characteristics for better classification of the groundwater resources of the Gwalior district.

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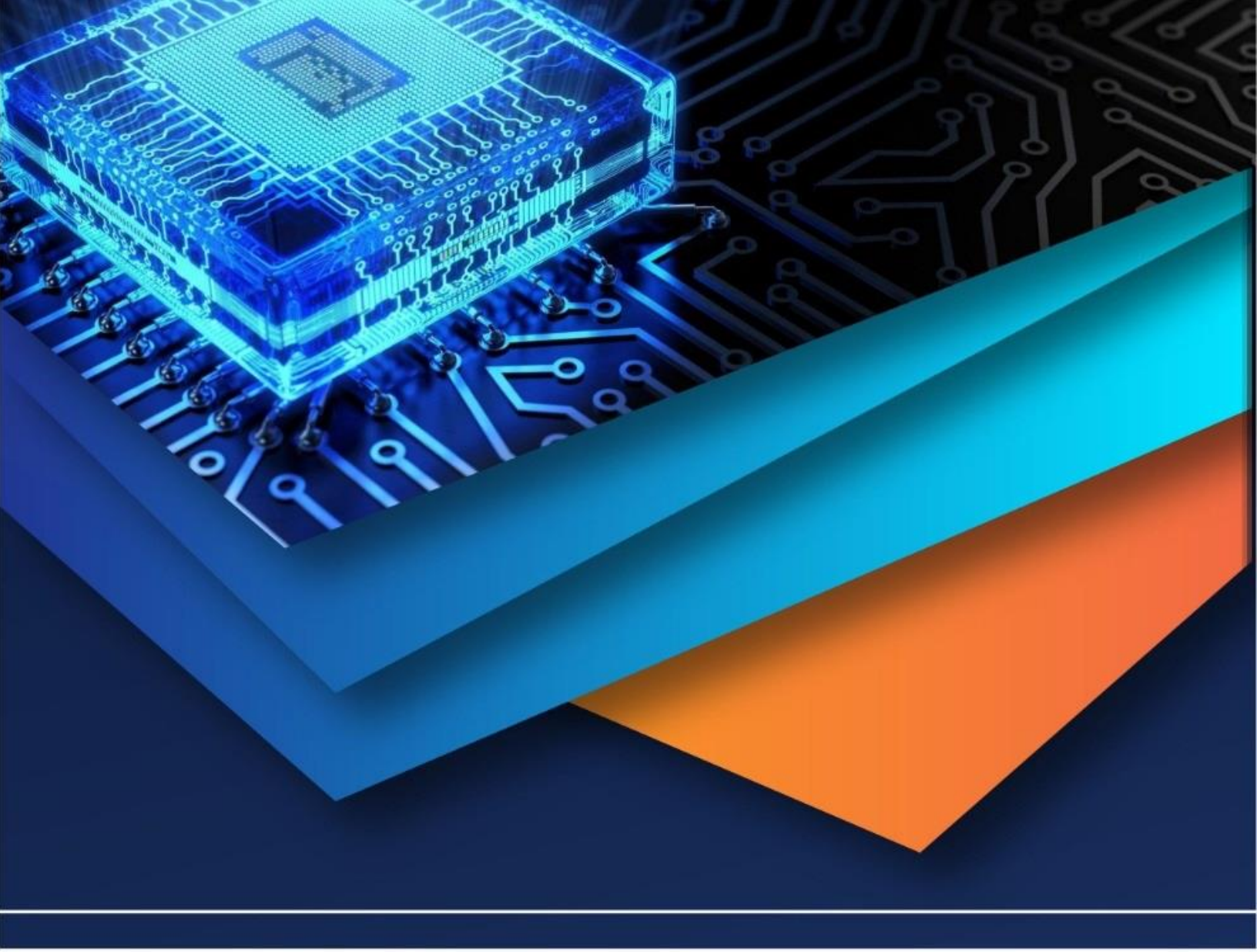

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