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WATER QUALITY INDEX FOR ASSESSMENT OF RAW WATER AT DIFFERENT CITIES IN M.P., INDIA

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ABSTRACT

The paper aims at determining the suitability of ground water of different zones in four cities with five sampling stations each of Madhya Pradesh with reference to index also termed as Water Quality Index (WQI). The objective of the index is to convert complex data pertaining to water quality into the most comprehensible and simple data that can be understood by general public and policy makers as a whole. The objective was to study different parameters viz. physicochemical, mineral, demand, nutrient, bacteriological and metals to check the pollution levels in the region using Water Quality Index (WQI). The WQI for few of the samples ranges between 25 – 50 indicating its bad quality while for other samples it was between 50 – 70, showing bad to medium water quality. The study revealed that all the groundwater sources studied are somewhat contaminated and are unfit for human consumption and requires assessment to some degree of purification before it is used for drinking and domestic purposes.

Keywords: *Ground water, Physico- Chemical characteristics, Pollution, Water Quality Index.*

I. INTRODUCTION

The quality of water is of utmost importance compared to quantity in any water supply planning, and especially for potable purpose purity is the prime requirement. The chemical, physical and bacterial characteristic of groundwater determines its usefulness for municipal, commercial, industrial, agricultural and domestic water usage [1]. Due to lack of proper operation and maintenance, the water supply systems are unable to run at their full capacity [2]. As fresh water will be a scarce in the future water quality monitoring program is necessary for the protection of fresh water resources [3 & 4].

In order to summarize water quality data in understandable format, number of measures (indices) have been devised. One such index is Water Quality Index (WQI) which was first mathematically developed by Horton as a means of deriving a single value from numerous test results .Similar to Ultra violet index or an air quality index; it can inform us about the potential threat to overall quality of water bodies. This index also helps to compare the data between various locations [4].

Horton 1965 used the arithmetic aggregation function for the WQI. He selected 10 most commonly measured water quality variables for his index including dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity, and chloride. The arithmetic weighing of the water quality variables was multiplied with the temperature and ‘‘obvious pollution’’ to obtain the sum aggregation function from which the overall water quality index was found out. Similar to Horton (1965), Brown et al. (1970) also employed basic arithmetic weighting, although without the multiplicative variables. This effort was supported by the National Sanitation Foundation (NSF) in which the water quality variables were chosen using the Delphi method, which generates results from the convergence of expert’s opinions. The NSF WQI used logarithmic transforms to convert water quality variable results into sub-index values [5, 6, 7 & 8].

The Water Quality Index (WQI) has been considered as one criterion for drinking water classification based on the use of standard parameters for water characterization. The WQI classification proposed by Department of

Environment, Malaysia has been used to assess the quality of major water supply sources indicating the level of pollution [9]. The National Sanitation Foundation (NSF) WQI was developed to provide a standardized method for comparing the water quality of various water sources based upon nine water quality parameters i.e. temperature, pH, dissolved oxygen, turbidity, faecal coliform, biochemical oxygen demand, total phosphates, nitrates and total solids. The water quality ranges have been defined as excellent, good, medium, bad and very bad.

II. MATERIALS AND METHOD

Sample Collection
Water samples were collected in pre-cleaned sterilized polypropylene bottles with necessary precaution from different sites. Samples were collected in monsoon as well as winter seasons. Various physico-chemical parameters are analysed as given in standard manual of water and waste water analysis [10].

Laboratory Analysis
The collected water samples analysed for ten parameters in the lab as per standard procedures [10].

Determination of Water Quality Index
WQI is a numeric expression used to transfer large quantity of water characterization data into a single number, which represents the water quality level [11 & 12]. WQI is a 100 point scale that summarizes results from a total of nine different measurements viz. temperature, pH, dissolved oxygen, turbidity, faecal coliforms, biochemical oxygen demand, total phosphate, nitrates and total solids [13, 14, 15 & 16]. Water quality factors with their corresponding weights are given in the following Table 1.

Table 1: Water Quality Index Calculators

Sr. No.	Factor	Weight
1	Dissolved oxygen	0.17
2	Fecal coli forms	0.16
3	pH	0.11
4	BOD	0.11
5	Temperature change	0.1
6	Total phosphate	0.1
7	Nitrates	0.1
8	Turbidity	0.08
9	Total solids	0.07

The 100 point index has been divided into several ranges corresponding to the general descriptive terms shown below.

Range	Quality
90 – 100	Excellent
70 – 90	Good
50 – 70	Medium
25 – 50	Bad
0 – 25	Very bad

For calculating WQI proposed by NSF an algorithm has to be followed
Step 1 : Calculate the water quality parameter value
Step 2 : Calculate quality value (Q-value) from the value function graph using a calculator (http://www.water-research.net/wterqualityindex/index.htm) for each parameter.
Step 3 : Multiply Q value by weight factor to get parameter sub-index.
Step 4 : Compute the WQI from the sum of sub-indices of parameters by the sum of weight factors for the parameters.

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III. RESULTS AND DISCUSSION

The results of analyses for 20 physico-chemical parameters for all the 20 samples for the 4 cities are given in Table 2 - 5. The results obtained were cross checked by the use of an automated workbook of water analyses [17]. The respective values for all the 20 parameters were compared with the standard limit recommended by Indian Standards for drinking water [18].

Table 2: Analysis results for Indore city.

Sr. No.	Parameters	Unit	Indore-1	Indore-2	Indore-3	Indore-4	Indore-5
			Kalindi Township	Baikund-dham Colony	Sudama Nagar	Nehru Nagar	Vijay Nagar
1	pH		7.07	6.75	7.36	7.41	7.13
2	Temperature	^{0}C	27	27	28	26	27
3	Conductivity	µs/cm	980	1004	520	1152	1065
4	Turbidity	NTU	1.2	0.7	ND	0.4	0.8
5	DO	mg/L	1.1	0.8	0.9	1.2	1
6	COD	mg/L	4	6	5	4	3
7	BOD	mg/L	< 2	< 2	< 2	< 2	< 2
8	Alkalinity	mg/L	141	118	94	470	301
9	TDS	mg/L	689	705	365	814	765
10	TSS	mg/L	8	7	3	10	6
11	Total Hardness	mg/L	255	265	112	336	325
12	Calcium	mg/L	60	60	32	88	61
13	Magnesium	mg/L	25	28	8	28	39
14	Chloride	mg/L	191	178	157	248	261
15	Sulphate	mg/L	40	84	18	97	28
16	Fluoride	mg/L	0.62	0.54	0.27	0.64	0.82
17	Iron	mg/L	0.2	0.12	0.21	0.33	0.08
18	Nitrate	mg/L	2.335	3.412	2.119	1.118	5.338
19	Phosphate	mg/L	0.056	0.117	0.042	0.227	0.178
20	Fecal Coliform	MPN/100ml	22	15	24	27	22
	WQI		54.44	50.84	47.15	52.00	49.01
	Water Quality		MEDIUM	MEDIUM	BAD	MEDIUM	BAD

Table 3: Analysis results for Bhopal city.

Sr. No.	Parameters	Unit	Bhopal-1	Bhopal-2	Bhopal-3	Bhopal-4	Bhopal-5
			Shahpura	Crompton and Greaves	DB CITY Mall	Railway Station	Courtyard by Mariott
1	pH		7.13	7.13	7.35	7.18	7.23
2	Temperature	^{0}C	27	28	26	27	27
3	Conductivity	µs/cm	1050	1035	1000	1020	1070
4	Turbidity	NTU	0.8	ND	1.6	0.4	0.5
5	DO	mg/L	0.7	0.6	1.4	1	0.8
6	COD	mg/L	4	8	3	5	7
7	BOD	mg/L	< 2	< 2	< 2	< 2	< 2
8	Alkalinity	mg/L	282	376	282	282	305
9	TDS	mg/L	765	732	707	715	750
10	TSS	mg/L	8	9	6	4	8
11	Total Hardness	mg/L	320	312	256	320	320

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12	Calcium	mg/L	80	60	60	80	60
13	Magnesium	mg/L	29	39	26	29	41
14	Chloride	mg/L	263	299	197	263	277
15	Sulphate	mg/L	32	33	19	26	35
16	Fluoride	mg/L	0.84	0.86	0.71	0.7	0.84
17	Iron	mg/L	0.16	0.23	0.03	0.15	0.02
18	Nitrate	mg/L	2.447	1.892	3.221	1.092	0.065
19	Phosphate	mg/L	0.092	0.048	0.074	0.018	0.043
20	Fecal Coliform	MPN/100ml	22	15	23	21	27
	WQI		52.39	48.06	53.10	57.93	59.67
	Water Quality		MEDIUM	BAD	MEDIUM	MEDIUM	MEDIUM

Table 4: Analysis results for Gwalior city.

Sr. No.	Parameters	Unit	Gwalior-1 Thatipur	Gwalior-2 Abhinandan Nagar	Gwalior-3 Railway Station	Gwalior-4 Substation Centre	Gwalior-5 Kotilya Nagar
1	pH		7.2	7.2	7.76	7.93	7.18
2	Temperature	^{0}C	27	28	26	27	26
3	Conductivity	µs/cm	740	770	590	600	750
4	Turbidity	NTU	0.2	0.4	0.1	0.2	0.4
5	DO	mg/L	0.4	1.2	0.6	0.9	1.6
6	COD	mg/L	6	7	8	4	4
7	BOD	mg/L	< 2	< 2	< 2	< 2	< 2
8	Alkalinity	mg/L	223	353	259	259	282
9	TDS	mg/L	510	537	408	401	507
10	TSS	mg/L	4	4	2	2	5
11	Total Hardness	mg/L	223	223	191	191	223
12	Calcium	mg/L	44	48	48	48	48
13	Magnesium	mg/L	27	25	17	17	25
14	Chloride	mg/L	139	161	94	87	131
15	Sulphate	mg/L	14	17	60	59	14
16	Fluoride	mg/L	0.53	0.63	0.7	0.71	0.5
17	Iron	mg/L	0.17	0.03	0.01	0.14	0.23
18	Nitrate	mg/L	1.567	4.892	2.776	ND	0.372
19	Phosphate	mg/L	0.032	0.077	0.031	0.008	0.011
20	Fecal Coliform	MPN/100ml	22	24	15	15	22
	WQI		56.72	52.09	55.78	51.15	60.21
	Water Quality		MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM

Table 5: Analysis results for Ujjain city.

Sr. No.	Parameters	Unit	Ujjain-1 Shir Sagar Colony	Ujjain-2 Arpita Nagar	Ujjain-3 Abhishekh Nagar	Ujjain-4 Nanakheda	Ujjain-5 RD Gardi
1	pH		7.21	8.18	8.42	8.06	7.93
2	Temperature	^{0}C	27	27	27	28	27
3	Conductivity	µs/cm	780	770	720	700	1155
4	Turbidity	NTU	0.2	0.4	0.3	0.2	0.8
5	DO	mg/L	0.9	1.2	0.8	0.7	1.3
6	COD	mg/L	3	6	3	8	6
7	BOD	mg/L	< 2	< 2	< 2	< 2	< 2

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8	Alkalinity	mg/L	353	306	329	259	342
9	TDS	mg/L	520	545	535	493	879
10	TSS	mg/L	6	8	8	6	12
11	Total Hardness	mg/L	152	160	142	187	351
12	Calcium	mg/L	40	48	28	44	57
13	Magnesium	mg/L	13	10	16	18	50
14	Chloride	mg/L	246	246	232	160	212
15	Sulphate	mg/L	45	40	46	42	44
16	Fluoride	mg/L	0.76	0.75	0.54	0.72	0.5
17	Iron	mg/L	0.16	0.13	0.19	0.21	0.04
18	Nitrate	mg/L	5.782	3.661	2.785	1.184	2.679
19	Phosphate	mg/L	0.047	0.053	0.008	0.017	0.078
20	Fecal Coliform	MPN/100ml	27	15	17.5	23	21
	WQI		52.91	53.64	54.09	56.75	52.88
	Water Quality		MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM

From the results the WQI indicates the "Bad" quality of water for water samples W-1, W-10, W-11 and W-12, "Medium" quality for water samples Indore-3, Indore-5 and Bhopal-2 while rest of the water samples show "Bad to Medium" water quality.

IV. CONCLUSION

The WQI for three samples ranges between 25 – 50 indicating its bad quality while other samples range between 50 – 70 showing bad to medium water quality

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