A Study on Ground Water Quality Comparison

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Abstract - Ground water quality is an important issue since the water directly reaches the consumers. The quality also changes from location to location making its prediction complicated. Successful studies of ground water quality prediction considering the ground water sampling as homogeneous instead of heterogeneous are available in literature. The present study is taken up comparing the quality parameters of ground water from source to consumer, considering ground water source as homogeneous. If there is no contamination in between, the quality parameters of the ground water at the source must be the same when it reaches to the consumer. An existing water supply network is considered and the water samples are analyzed and compared for their suitability for the above assumption. A theoretical analysis is also carried out for additional comparison. Encouraging results are obtained from the study. It is noted that such similarity exists particularly in a micro-scale subjected to reliability of the existing data.

1. INTRODUCTION

Domestic and Industry users of water are concerned about the groundwater quality since it is being consumed in many parts of the country, without any treatment. Groundwater quality is being changed in the country due to (i) indiscriminate disposal of industrial effluents (ii) increasing salinity due to sea water intrusion [7]. The water quality both at the source and consumer end are of high importance. The differences in the water quality can be attributed to the problems associated during the conveyance and distributions. Groundwater quality depends on the type of polluting sources in the surroundings and hence changes from location to location. The physico-chemical parameters of groundwater such as pH, Chlorides, Sodium, Calcium, Magnesium, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Fluoride etc subsequently varies from location to location [7].

Ramakrishna [7] and Ramakrishna et al., [6] studied the relationship among the various physico-chemical parameters of the ground water using regression and artificial neural networks and observed that the theoretical relationship among the physico-chemical parameters of ground water follows a similar trend that can be predicted. The most important aspect of this study is that it is assumed that the source of water is same while sampling is done at different locations. This assumption assumes the source to *homogeneous* but actually it is *heterogeneous* as the sampling is done at different places for the ground water that is locally available in that area. Based on the encouraging results obtained from their study under these assumptions, a simple case is taken up for understanding the variations in ground water quality both at source and at the consumer end from a township of an educational Institution in Rajasthan.

2. PROBLEM SCOPE AND METHODOLOGY

The water supply in the residential campus consists of water taken from ground water wells which are pumped into reservoirs from where the water is discharged to different consumers such as offices, hostels etc. In the present study, six wells (W1-W6), three reservoirs (R1-R3) and thirteen consumer sources (S1-S9, O1-O4) are considered. The existing network that connects these sources is given in Fig.1 and the quantity of water that is being collected and discharged is compiled [8]. The details are presented in Table-1. Water samples from all these sources are collected and four parameters such as Hardness, Calcium, Chlorides and Fluorides are considered in the present study to observe the variations at the source and consumer ends.

3. RESULTS AND DISCUSSION

The water samples collected from the wells, reservoirs and consumer sources are analyzed in the laboratory for the identified four major parameters viz., Hardness, Calcium, Chlorides and Fluorides. The results for the wells W1-W5 are given in Table-2. The hardness, calcium and chlorides values are rounded-off to the nearest integer.

The experimental values are compared with those of theoretical values. For calculating the theoretical values the following simple procedure is adopted.

Table-2: Water quality of ground water wells

Well No	Reservoir No	Hardness mg/L	Calcium mg/L	Chlorides mg/L	Flourides mg/L
W1	R1	175	21	220	1.5
W2	R2	233	31	303	0.9
W3	R2	321	23	281	0.6
W4	R2	290	21	222	0.7
W5	R3	176	24	128	1.0

Suppose two wells are connected to single reservoir. And the total supply to the reservoir is 1000 liters, both the wells supplying 500 liters each. Let the hardness values for the two wells are 100 mg/L and 120 mg/L respectively.

Therefore the theoretical value of hardness for the reservoir is computed [4] as-

$$= ((500 \times 100) + (500 \times 120)) \div (500 + 500) = 110 \text{ mg/L}.$$

The theoretical values of the water quality parameters for the reservoirs are calculated using the data given in Table-1 and are presented in Figures-1& -2. It can be noted from Fig.1& 2 that there s an agreement with the theoretical actual values except for R2 for calcium, which may be considered as an experimental error. But the similarity and closeness of the results both theoretical and actual values proves the validity of the formula used for estimating the values and also the agreement of the concept considered for comparison of the values.

Similar procedure is adopted for comparing the values for the consumer sources. Here three comparisons are considered (i) actual (experimental) value of the reservoir (ii) theoretical value of the reservoir (iii) actual (experimental) value of the consumer source. For laboratory analysis of the water samples, only the consumer sources S1-S9 are considered while the sources O1-O4 are ignored based on the local significance of these sources. The results are given in Table-3.

It is noted from Table-3 that, the values for hardness, chlorides and fluorides are in close agreement for all the three different cases mentioned above for all the sources S1-S9. The average value is computed for 'c' category ie., actual value at the source to understand the deviation of the value from others. The value is showing a maximum deviation of only ± 15%, which can be considered encouraging based on the type of studies that are conducted.

It can be observed from Table-3 and Fig.1 and 2 that, a close consistency of the values is maintained barring a few experimental errors. The water supply points and piping system needs a close look for maintenance due to high experimental values of calcium. Hard water is high in calcium and magnesium contributions [9]. The average value of total hardness tested in this study is 173, 268 and 176 mg/L for R1, R2 and R3 respectively (Refer Table-3). This shows that the water can be classified as hard-very hard based on these values [2,5]. The results showed inconsistency with the high calcium values. They are in close agreement for values at reservoir and at source but showed a remarkable deviation for the theoretical values computed for the reservoir. The errors that have creeped in the existing data which has been supplied by the water supply works department of the Institute might have had a slight impact on the computation of theoretical results when the comparisons are made at the consumer points.

High calcium in water leads to deposits in pipes [2, 3, 4]. A similar observation was made by Babu and Ramakrishna [1] in their studies leading to alternate arrangement in the pipes for the Heat exchanger systems provided in the same campus. The present study showed experimentally that the scaling problem in the pipes is existing due to high calcium and hardness in the campus. This scaling problem will offer difficulty in cleaning and will subsequently increase the water pressure in piping systems. Further, uptake of excess calcium per day can lead to the development of kidney stones and sclerosis of kidneys and blood vessels [3].

The present system of estimating the water pumping by the concerned needed improvement where systematic efforts need to be introduced. Periodical calibrations are to be maintained to take into wear and tear of the pumping equipment taking into consideration the calcium deposits in the pipe sections.

The information that is obtained from the present study shows that effective maintenance measures are essential when handling hard waters. The results obtained from the study are helpful in terms of estimating the future needs of the campus in terms of expansion of facilities.

It can be thus be concluded from the present study that-

- Comparison of values of water quality parameters between those at source and at consumer is possible
- The maintenance of the water supply system plays an important role for understanding and taking steps to prevent problems such as scaling etc.
- Hardness and calcium are important parameters to be considered for both water quality and maintenance point of view
- Regular servicing of pumping equipment is desired in water supply systems

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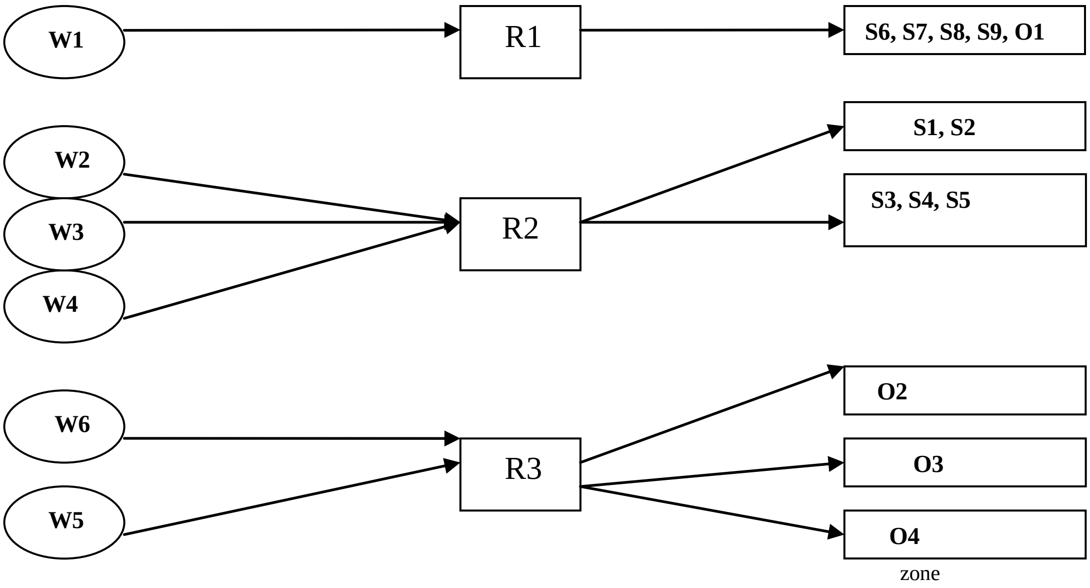

Fig.1: Network of water supply system in the study

Table-1. Sources of water and quantities of water supplied

Reservoir No	Quantity of water supply from well to Reservoir		Quantity of water supply from Reservoir to Consumers	
	Well No	Water supply (Liters)	Water supply (Liters)	Consumers
R1	W1	306617	299946	S6, S7, S8, S9
			7571	O1
R2	W2	11356	94635	S1, S2
	W3	255514	227124	S3, S5
	W4	56781		S4
R3	W6	56781	3785	O2
	W5	272549	18927	O3
			306617	O4

S1-9: Sources of water sampling, O1-4: Other sources

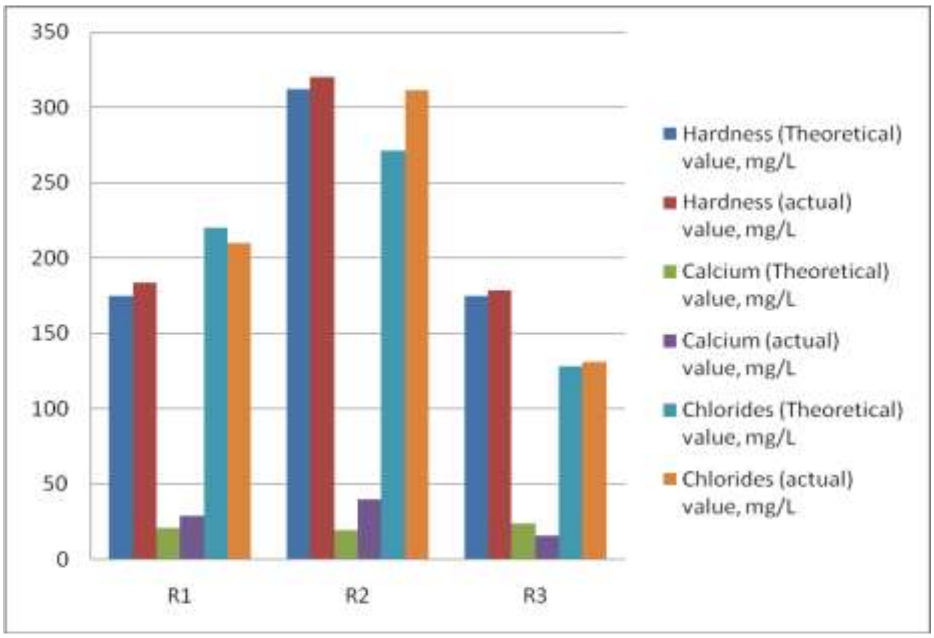

Figure-1: Comparison of Reservoir water quality for both theoretical and actual values

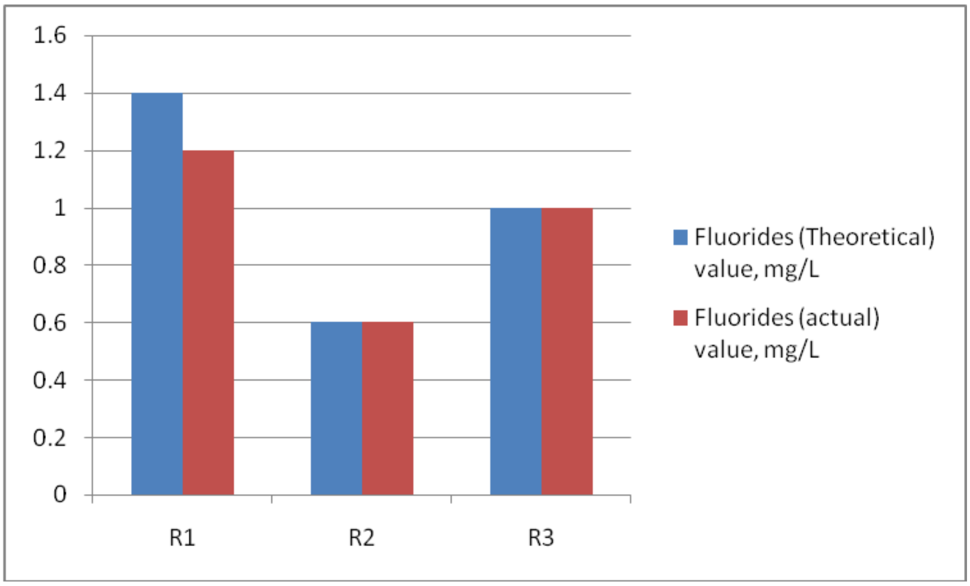

Figure-2: Comparison of Reservoir water quality for both theoretical and actual values

Table-3: Comparison of water quality parameters for the consumer sources

Consumer Source	**Res No**	**Hardness (mg/ L)**			**Calcium (mg/ L)**			**Chlorides (mg/ L)**			**Fluorides (ppm)**		
		(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
S1	R2	320	312	280	40	20	44	311	271	335	0.6	0.6	0.8
S2	R2	320	312	240	40	20	41	311	271	283	0.6	0.6	1.0
S3	R2	320	312	274.	40	20	73	311	271	301	0.6	0.6	0.8
S4	R2	320	312	252	40	20	26	311	271	274	0.6	0.6	1.0
S5	R2	320	312	294	40	20	72	311	271	286	0.6	0.6	1.0
Average				268			51			296			0.9
S6	R1	184	175	152	29	21	23	210	220	197	1.2	1.4	1.0
S7	R1	184	175	164	29	21	25	210	220	226	1.2	1.4	1.0
S8	R1	184	175	180	29	21	25	210	220	206	1.2	1.4	1.0
S9	R1	184	175	196	29	21	23	210	220	193	1.2	1.4	1.0
Average				173			24			206			1.0
W5	R3*	179	176	176	16	25	25	131	129	128	1.0	1.0	1.0

(a)- Actual value of the reservoir; (b)- Theoretical value of the reservoir; (c)- Actual value of the source
* Well only but not reservoir