ONE WAY ANALYSIS OF VARIANCE OF CRITICAL PARAMETERS OF ON SITE SANITATION SYSTEM – A CASE STUDY

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ABSTRACT

In the present study three periurban areas were selected to study the effect of onsite sanitation on borewell water quality. Bore well samples were collected from the peri urban areas and were analysed for critical onsite sanitation parameters like nitrate, chloride and total count. Minitab version 17 was used to run One way Analysis of Variance (ANOVA) at 95% confidence interval. to determine the significance levels of parameters in both spatial (between bore wells and pit latrines) and seasonal variations. In the study areas it was observed from one way analysis of variance test that chloride concentration varied with distance and season and was significant with both distance and season, while distance had highest significant effect. It was observed from the analysis of variance test that both season and distance has significant effect on nitrate concentration. Between the two, distance had higher significant effect when compared with season. Both season and distance had significant effect on total count concentration and was affected more by season than distance.

KEY WORDS : Onsite sanitation, Nitrate, Chloride, Total count, Peri urban areas

INTRODUCTION

The on-site sanitation, poses threat to groundwater water sources. The on-site sanitation causes contamination of groundwater due to pathogens or nitrate or both. Many researches are carried out the work to predict the effect of on-site sanitation system on groundwater quality. (Dyer, 1941; Lewis *et al.*, 1982; Chidavaenzi *et al.*, 1997; Lawrence *et al.*, 2001 Still DA and Nash SR. 2002; Pujari *et al.*, 2012; Banerjee, 2011; Sudhakar M Rao *et al.*, 2013; Pantaleo *et al.*, 2018; Alfonse Tapera Ndoziya *et al.*, 2019).

During assessing the impact of onsite sanitation system on groundwater quality, the critical parameters like chloride, nitrate, and fecal coli forms were used by most of the researchers (Lewis *et al.*, 1988; Lawrence *et al.*, 2001 NEERI, 2005).

The extent of groundwater pollution depends on depth to water table, season of the year, hydro geology, soil matrix, and distance between borewells and septic tank/pit latrine. The travel of bacteria from underground leach pit is dependent on soil conditions; hydraulic gradient, groundwater table and type of soil (Banerjee, 2011).Various researchers have suggested the travel distance and presence of coli form from onsite sanitation system (Dyer, 1941; Chidavaenzi, 1997; Still and Nash, 2002; Banerjee, 2010). They observed that travel distance of coli form from septic pit varied from 1 to 25m depending upon soil type, seasons of year and geoenvironmental conditions.

In the present research work field studies were carried out in periurban area to determine critical parameters of onsite sanitation and effects of season of year, depth of bore well and distance between borewell and septic tank /pit latrine on critical parameters were studied by using One Way Analysis of Variance (ANOVA).

STUDY AREA

In the present study peri urban areas selected are Doddaballapura Taluk Headquarters and Hosakote

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taluk head quarters and Kanakapura headquarters. The details of study areas are presented in the Table 1.

Methodology

After preliminary survey, about 9 to 12 bore well water sampling locations were selected in each



Study area map

Sl. No.	Study Area	Population	Geographical area.in sq Km	Latitude and longitude	Soil type	Geology	Rainfall mm	No of borewells
1	Doddaballapura Taluk Headquarter Bangalore Rural District	85,000 's	18	77° 322 34.83 E 13°17231.23 N	Sandy loamy	Tonalitic gneisses and gneisses	768	9
2	Hosakote taluk head quarters Bangalore Rural District	56,613	18.25	77° 322 34.83 E 13° 172 31.23 N	laterite gravelly clay	gneisses and laterite	768	12
3	Kanakapura headquarters Ramanagara District	70,150	7.8	12.55°N 77.42° E	granodio and gran	rite ite	750	11

study area and ground water samples were collected on monthly basis for two years. Samples were collected in 2-Litre polypropylane plastic bottle for physiochemical parameters analysis. 300 ml sterilized bottle was used for collection water sample for bacteriological study.

The standard methods was followed during collection, storage, preservation and analysis of borewell samples. The borewell samples were analysed for critical on site parameters like chloride, nitrate and total count. Minitab version 17 was used to run One way Analysis of Variance (ANOVA) at 95% confidence interval to determine the significance levels of parameters in both spatial (between bore wells and pit latrines) and seasonal variations.

RESULTS AND DISCUSSION

Critical parameters of onsite sanitation of Doddaballapura study area

Chloride: The average chloride concentration varied between 120 to 560 mg/l in premonsoon, 105 to 530 mg/l in monsoon and 125 to 565 mg/l in post monsoon seasons. Maximum values of chloride were observed in premonsoon season. The concentration of chloride in groundwater was high possibly due to domestic waste leaching from upper soil layers in the dry climate. The values of chloride observed in the observation wells established by Central Ground Water Board were 42 to 1187 mg/l, which were similar to the results observed during the study period.

Nitrate: Average nitrate concentration varied between 3.2 to 58 mg/l in premonsoon, 22 to 43.1 mg/l in monsoon and 3 to 45 mg/l in post monsoon. Maximum values of nitrate were observed in pre monsoon season. The values of nitrate observed in the observation wells established by Central Ground Water Board were in the range of 11.87 to 42 mg/l, which were similar to the results observed during study period.

Total count: According to WHO (2003), drinking water from untreated sources like bore well was considered be safe when total count was 1 in 10 per 100 ml. Average total count concentration varied between 2/100 ml and 7/100 ml in premonsoon, 2/ 100 ml and 15/100 ml in monsoon and 2/100 ml and 11/100 ml in post monsoon seasons. The presence of total count had been observed in the entire study area and nearest to onsite sanitation system. This

could be due to lesser distance between source and receptor. Hence the presence of total coli form could due to infiltration of leachate from onsite sanitation systems. The average total coli form in monsoon was higher compared to post and premonsoon seasons.

Critical parameters of onsite sanitation in Hosakote study area

Chloride: The average chloride concentration varied between 85 to 1622 mg/l in premonsoon, 190 to 1240 mg/l in monsoon and 120 mg/l to 990 mg/l in post monsoons. Average chloride exceeded desirable limit of drinking water at all the stations. The values of nitrate and chloride observed in the observation wells established by Central Ground Water Board were in the range of 137 to 498 mg/l, which are similar to the results observed during the study period.

Nitrate: The average nitrate concentration varied between 7 to 67 mg/l in premonsoon, 9.5 to 56.10 mg/l in monsoon and 10 to 58 mg/l in post monsoon seasons. Maximum values of nitrate were observed in pre monsoon season. The values of nitrate observed in the observation wells established by Central Ground Water Board were 10 to 296 mg/ l, which were similar with the results observed during the study period.

Total count: The average total count concentration varied between 4/100 ml and 15/100 ml in premonsoon, 3/100 ml and 14/100 ml in monsoon and 2/100 ml and 11/100 ml in post monsoon seasons. Maximum values of total count were observed in monsoon season. The presence of total count was observed in all bore well water samples in the entire study area and nearest to the onsite sanitation system. This could be due to the lesser distance between source and receptor. Hence the presence of total coli form could be due to infiltration of leachate from onsite sanitation systems. Average total coli form in monsoon is more compared to post and premonsoon seasons.

Critical parameters of onsite sanitation of Kanakapura study area

Chloride: The average chloride concentration varied between 60 to 545 mg/l in premonsoon, 60 to 470 mg/l in monsoon and 73 to 800 mg/l in post monsoon seasons. In the study area 80 % sampling stations had average chloride value more than permissible limit (250 mg/l). **Nitrate:** The average nitrate concentration varied between 5 to 68 mg/l in premonsoon, 3 to 49 mg/l in monsoon and 4.6 to 45 mg/l in post monsoon seasons. The maximum values of nitrate were observed in post monsoon season.

Total count: The average total count concentration varied between 2/100ml and 11/100 ml in premonsoon, 2/100 ml and 26/100 ml in monsoon and 2/100 ml and 11/100 ml in post monsoons seasons. The presence of total count was observed in the all bore well water samples in the entire study area and to nearest to the onsite sanitation. Hence the presence of total coli form could be due to infiltration of leachate from onsite sanitation

systems. Average total coliform in monsoon was more compared to post and premonsoon.

One way Analysis of Variance (ANOVA) of critical parameters of onsite sanitation system Doddaballapura study area

Analysis of variance test comments

From the analysis of variance test, it was seen (Table 2) that chloride concentration varied with distance and season and was significant with both distance and season, while the distance had highest significant effect. It was seen (Table 3) from the analysis of variance test that both season and

Table 2. One way Analysis of variance of chioride of Doddaballapura study are	Table 2. One wa	⁷ Analysis of	Variance of	chloride of	Doddaballapur	a study area
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Sourco	DE	14:55	A di MS	E Value	P Value
Source	DF	Auj 55	Auj 1vi3	F-value	r - value
Season	6	40400	6733	4.36	0.001
Distance	8	427941	53493	34.61	0.000
Error	46	71101	1546		
Total	60	542008			

DF=Degree of freedom for effect or errors

Adj SS=Sum of squares

Adj MS=Mean square error

F-Value= Ratio of two mean squares M.S. of fitted model/ Mean square error

P-Value=Significant value

F test indicates that significant difference exist between group means.

Table 3. ANOVA of nitrate in Doddaballapura study area

DF	Adj SS	Adj MS	F-Value	P-Value
6	1918.5	319.74	19.62	0.000
8	4349.0	543.62	33.35	0.000
46	749.8	16.30		
60	7053.5			
	DF 6 8 46 60	DF Adj SS 6 1918.5 8 4349.0 46 749.8 60 7053.5	DF Adj SS Adj MS 6 1918.5 319.74 8 4349.0 543.62 46 749.8 16.30 60 7053.5 16.30	DF Adj SS Adj MS F-Value 6 1918.5 319.74 19.62 8 4349.0 543.62 33.35 46 749.8 16.30 60 7053.5

Table	4. ANC	VA of	total	count in	Doddabal	lapura s	study area	

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Season	6	174.51	29.085	22.79	0.000
Distance	8	48.43	6.053	4.74	0.000
Error	46	58.71	1.276		
Total	60	291.31			

One way Analysis of Variance of critical parameters of onsite sanitation in Hosakote study area

Table 5. ANOVA of nitrate in Hosakote study area

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Season	7	2161	308.77	11.75	0.000
Distance	11	2091	190.06	7.23	0.000
Error	65	1708	26.28		
Total	83	6084			

distance had significant effect on nitrate concentration. Among both season and distance, it was noticed that, distance had higher significant effect than season. Both season and distance had significant effect on the total count concentration and was affected more by season than distance (Table 4).

Analysis of variance test comments

From the analysis of variance test, it was seen (Table 5) that chloride concentration varied with distance and season and was significant with both distance and season, while distance had highest significant

effect. It was seen (Table 6) from the analysis of variance test both season and distance had significant effect on nitrate concentration. Among both season had highest significant effect than distance. Both season and distance had significant effect on total count concentration and was affected more by season than distance (Table 7).

Analysis of variance test comments

From the analysis of variance test, it was seen (Table 8) that chloride concentration varied with distance and was significant with distance, while season did not have any significant effect. It was seen (Table 9)

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Source	DF	Adj SS	Adj MS	F-Value	P-Value			
Season	7	54682	7812	5.26	0.000			
Distance	11	4531321	411938	277.63	0.000			
Error	65	96443	1484					
Total	83	4683959						

Table 6. ANOVA of chloride in Hosakote study area

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Season	7	28.32	4.0453	5.63	0.000
Distance	· 11	30.75	2.7951	3.89	0.000
Error	65	46.71	0.7187		
Total	83	107.06			

Table 7. ANOVA of total count in Hosakote study area

One way Analysis of Variance of critical parameters of onsite sanitation in Kanakapura study area

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Source	DF	Adj SS	Adj MS	F-Value	P-Value			
Season	6	25515	4253	0.76	0.602			
Distance	10	362040	36204	6.50	0.000			
Error	60	334336	5572					
Total	76	721891						

Table 8. ANOVA of chloride in Kanakapura study area

Table 9. ANOVA of nitrate in Kanakapura study area

DF	Adj SS	Adj MS	F-Value	P-Value
6	3627	604.58	19.15	0.000
10	3666	366.56	11.61	0.000
60	1894	31.57		
76	9188			
	DF 6 10 60 76	DF Adj SS 6 3627 10 3666 60 1894 76 9188	DF Adj SS Adj MS 6 3627 604.58 10 3666 366.56 60 1894 31.57 76 9188 31.57	DF Adj SS Adj MS F-Value 6 3627 604.58 19.15 10 3666 366.56 11.61 60 1894 31.57 76 9188

Table 10. ANOVA of total count in Kanakapura study area

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Season	6	227.0	37.831	6.72	0.000
Distance	10	203.2	20.317	3.61	0.001
Error	60	337.8	5.630		
Total	76	768.0			

from analysis of variance test that both season and distance had significant effect on nitrate concentration. Among both, season had highest significant effect than distance. Both season and distance had significant effect on the total count concentration and was affected more by season than distance (Table 10)

CONCLUSION

In the study areas it was observed from one way analysis of variance test that chloride concentration varied with distance and season and was significant with both distance and season, while distance had highest significant effect. It was observed from the analysis of variance test that both season and distance has significant effect on nitrate concentration. Between the two, distance had higher significant effect when compared with season. Both season and distance had significant effect on total count concentration and was affected more by season than distance.

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