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PHYSICOCHEMICAL AND BACTERIOLOGICAL ANALYSIS OF OPEN WELL WATER TO ASSESS POTABILITY IN THE SELECTED GRAMA PANCHAYAT OF THRISSUR DISTRICT, KERALA

Emily K. T.[1] and Dr. Subin M.P.[2]
[1]Research Scholar, R &D Centre, Bharathiar University, Coimbatore, Tamil Nadu.
[2]Assistant Professor in PG Dept. of Botany and Research, S.N. College, Nattika, Thrissur, Kerala.

ABSTRACT

Ground water is generally considered as safest among the various sources of water. But in the present days, due to unscientific waste disposal and improper sanitization measures, widespread reports of ground water contamination have increased public concern on drinking water quality. The study was under taken in these circumstances to analyze the drinking water quality status of open well water sources in three selected Grama Panchayat belonging to Thrissur district. Various physicochemical and bacteriological parameters of open well water samples from selected Grama Panchayats are analyzed. Standard methods described by APHA are used to analyze the physicochemical parameters while bacteriological parameters are analyzed using Membrane Filtration Method. The results obtained have been compared with prescribed standards for drinking water. The selected open well water sample from Veloor Grama Panchat was found safe while well water samples of Kattakambel and Chowannur Grama Panchayats were found unsafe as many physicochemical and bacteriological parameters are not satisfying the BIS standards for drinking water. Leaches from carelessly disposed wastes and improper sanitization measures may be the major reason. The study revealed careless waste disposal and other man made activities seriously polluted open well water sources in many areas of Kattakambel and Chowannur Grama Panchayats. The study suggests immediate action and pretreatment of open well water sources before consumption.

KEY WORD: *Open Well Water, Drinking Water Quality, Physicochemical, Bacteriological Analysis, Water Pollution.*

INTRODUCTION

The groundwater is believed to be comparatively safe and clean among the various sources of water for drinking and other domestic purposes, as it is assumed to be least affected by external anthropogenic activities. The process of percolation, which results in filtration and purification of water, is the main reason why ground water is often considered safer for human use (Kegley and Andrews, 1997). However many of the recent research works revealed that several factors like unscientific agricultural practices, domestic and industrial waste discharges, solid waste dumping, improper sanitization measures together with poor infiltration quality of the soil in the area can affect the quality of ground water. Even today a major part of the population both in the rural and urban use open well water as one of the mainsource of water for drinking and other domestic purposes. Therefore the study on open well water quality parameters is necessary to determine the extent of pollution, if any, so as to monitor the likely danger to the humans. In

view of the growing concern on the quality of water consumed, the present study was decided to be carried out to evaluate the water quality status of open well water in the three selected Grama Panchayats belonging to Thrissur district, Kerala. The study analyses the physical, chemical and bacteriological parameters of selected open well water to assess its potability for human consumption.

MATERIALS AND METHODS

Study Area and Well Water Sample Collection

Study area is three selected Grama Panchayats in Thrissur District, Kerala - Kattakambel, Veloor and Chowannur. Well water samples were collected from four open wells of different locations in each Grama Panchayat during the pre-monsoon and post-monsoon period .The period selected wasMarch-April 2017 with respect pre-monsoon and August-September 2017 with respect to Post-monsoon. High grade plastic bottles of one liter capacity were used to collect well water samples. The bottles were rinsed once using distilled water and then thrice using the water from the respective wells. While collecting the water samples, the bottles were completely immersed in the respective water samples to avoid trapping of air within the bottles.

Table 1: Details of Study Area and Open Well Water Samples

Grama Panchayat	Open Well Water Sample Code	Details of Open Well Water Sample Collection
Kattakambel	OWW-1	Four well water samples from four different open wells located in different locations were collected from each selected GramaPanchayath, during the pre-monsoon (March-April) and post-monsoon (August-September) period of 2017
Veloor	OWW-2	
Chowannur	OWW-3	

Analysis of Physico-Chemical Parameters

Various physic-chemical parameters analyzed for the selected open well water samples include pH, electrical conductivity (EC), turbidity, total hardness (TH), total alkalinity (TA), calcium, magnesium, chlorides, sulphates, nitrates, iron, total dissolved solids (TDS), dissolved oxygen (DO) and biochemical oxygen demand (BOD). Analysis was carried out using standard methods of American Public Health Association (2005). Each data presented in the resultagainst different parameters in respective of each Grama Panchayat is an average of four different data obtained from the analysis of four different well water samples.

Table 2: Physico-Chemical Parameters, Analytical Methods and Drinking Water Standards as per Guidelines of BIS (2012)

Physico-Chemical Parameter	Method of Analysis	BIS IS: 105002 (2012)	
		Desirable Limit	Maximum Limit
pH	Electrometric	6.5-8.5	No relaxation
EC	Electrometric	--	--
Turbidity	Nephelometric method	5	10
Total Hardness	Titration by H2SO4	300	600
Total Alkalinity	Titration by H2SO4	200	600
Calcium	Titration by EDTA	75	200
Magnesium	Titration by EDTA	30	100
Chlorides	Titration by AgNO3	250	1000
Sulphates	Turbidimetric	200	400
Nitrates	UV-VIS Spectrophotometer	45	100
Iron	Calorimetrically	0.3	1.0
TDS	Electrometric	500	2000
DO	Winkler method	≥5.0	No relaxation
BOD	5 days incubation at 20^0C followed by titration	≤1.0	No relaxation

Analysis of Bacteriological Parameters

Total coliforms (TC), faecal coliforms (FC) and Escherichiacoli (EC) count were the different bacteriological parameters selected and analyzed for the open well water samples collected. The procedure described in the Membrane Filtration Method (ISO, 1990) was adopted for the analysis of different bacteriological parameters. 10 ml of the well water sample directly or after dilution is introduced aseptically into a sterile filtration assembly containing a sterile membrane filter of 0.2 or 0.45mm pore size. The sample is then drawn through the membrane filter by applying a vacuum for holding indicator organisms on or within the membrane filter. Transfer this membrane filter to a suitable selective culture medium in a petri dish. The petri dish is then subjected to a period of resuscitation for the acclimatisation of indicator organisms to the new conditions. This is followed by the incubation of petri dish at suitable temperature and period of time to allow the replication of indicator organisms. The colonies formed are then identified and counted. The results are expressed in numbers of CFU per 100 ml of original sample.

Results and Discussions

The details of result obtained from the analysis of various physico-chemical parameters in the open well water samples of Grama Panchayat - Kattakambel (OWW-1), Veloor (OWW-2) and Chowannur (OWW-3) are shown in the Table-3.

Table-3

Physico-chemical Parameters	Study Area (GramaPanchayat) and season					
	Pre-monsoon			Post-monsoon		
	Kattakambel (OWW-1)	Veloor (OWW2)	Chowannur (OWW-3)	Kattakambel (OWW-1)	Veloor (OWW2)	Chowannur (OWW-3)
Turbidity(NTU)	4.05±0.21	0.1±0	1.4±0.28	5.6±0.28	0.1±0	1.65±0.21
TH(mg/l)	90.5±7.5	27±4.24	41±7.07	140.5 ±12.5	22.5±.7	44.5±4.94
TA(mg/l)	214.5±9.19	31±2.82	63.5±16.3	267.1±18.3	21.03±2.07	102.06±5.0
Ca(mg/l)	73.05±7.56	6.86±0.04	18.60±1.4	112.73±8.6	4.86±0.42	24.02±3.37
Mg(mg/l)	35.11±3.57	2.42±0.37	6.45±1.03	47.38±4.26	1.3±0.16	3.48±0.31
Cl(mg/l)	89.43±4.21	23.3±2.77	37.13±3.2	135.96±17.6	11.56±0.91	48.81±1.70
SO4(mg/l)	1.75±0.61	2.89±0.04	2.9±0.14	4.57±0.99	2.16±0.68	4.97±0.48

NO_3(mg/l)	46.78±3.37	8.99±0.75	1.48±0.16	53.86±5.52	6.99±0.55	2.02±0.11
EC(ms)	3.25±0.35	0.1±0	0.4±0.14	4±0.28	0.1±0	0.8±0.14
pH	5.52±0.17	6.78±0.23	5.86±0.19	5.8±.05	7.04±0.14	6.06±0.08
Fe(mg/l)	0.87±0.04	0.25±1.42	1.25±0.70	1.11±0.01	0.23±0.02	1.34±0.04
TDS (mg/l)	578±42	122.5±7.8	146.5±7.8	745±39.59	112±5.65	178.5±9.19
DO(mg/l)	1.8±0.28	6.25±0.21	3.45±0.21	1.45±0.07	6.3±0.14	3.9±0.42
BOD(mg/l)	6.7±0.28	1.9±0.14	3.75±0.21	7.2±0.35	1.7±0.1	3.7±0.28

The turbidity values of open well water samples presented in the Table-3 shows the ranges from 0.1NTU to 4.05NTU and 0.1NTU to 5.6 NTU respectively during the pre-monsoon and post-monsoon. The highest average value 4.05NTU and 5.6 NTU in the pre-monsoon and post-monsoon period was recorded in the OWW-1 of Kattakambel Grama Panchayat while the lowest turbidity was recorded in the OWW-2 of Veloor Grama Panchayat. With the exception of water sample OWW-1which exceeded the desirable limit during the post-monsoon period, all other values of turbidity recorded in the study are found well within the desirable limit. According to WHO (1993), the turbidity of drinking water shouldn't be more than 5 NTU, and should ideally be below 1 NTU. The higher turbidity level in the OWW-1 of Kattakambel particularly in the post-monsoon period is probably due to the intruded suspended and colloidal matter. This is harmful as it may contain certain heavy metals and biocides and further possibility to harbour certain pathogenic microorganisms and provide them protection from disinfection activities (Sadar, 1996).

Total hardness of well water samples showed the highest average value recorded in OWW-1 and the lowest value in OWW-2. The hardness values found ranged from 27mg/l to 90.5mg/l and 22.5mg/l to 140.5mg/l during the pre-monsoon and post-monsoon period respectively. Therefore the total hardness of all the well water samples is well within the desirable limit as per BIS standards (table 2). According to Thomas (1953), the hardness of water belonging to the range of 0 to 59mg/l is considered as soft; 60 to 119mg/l as medium hard; 120 to 179mg/l as hard and 180mg/l and above as very hard. In this respect, the hardness of water samples in the Kattakambel Grama Panchayath can be considered as medium hard in the pre-monsoon period while they changed to hard in the post-monsoon period. Comparatively higher value of hardness in the OWW-1 sample over OWW-2 and OWW-3 may be due to higher concentrations of Ca, Mg, and Fe. The total alkalinity (TA) values recorded in the well water samples varied from 31mg/l to 214.5mg/l during the pre-monsoon period and 21.03mg/l to 267.1mg/l during the post-monsoon period. The desirable level of total alkalinity for drinking water prescribed by BIS is 200mg/l while the maximum level is 600mg/l. The study recorded maximum TA in OWW-1 of Kattakambel during the pre-monsoon and post-monsoon and is 214.5mg/l and 267.1mg/l respectively. Both the values of OWW-1 exceeded the desirable limit but are within the maximum permissible limit while well water samples OWW-2 and OWW-3 recorded values which are well within the desirable level (Table-3). The undesirable alkalinity level in OWW-1 may be attributed to the excess concentration of various ions associated with careless waste disposal particularly sewage effluent discharge. Excess alkalinity may cause deleterious effect to humans particularly when the pH, total dissolved solids and hardness are higher in the water.

The desirable and maximum permissible limit of chlorides in natural drinking water prescribed by BIS is 250mg/l and 1000mg/l respectively, while for sulphates is 200mg/l and 400mg/l respectively. The concentrations of chlorides and sulphates of analyzed water samples presented in the table 3 indicate, all are well within the desirable limit and safe with comparatively higher values of chlorides recorded in the OWW-1 and sulphates in OWW-3. However the average concentration values of calcium, magnesium and nitrates were found not desirable in the well water samples of Kattakambel Grama Panchayath. The concentrations of magnesium and nitrates exceeded the desirable level but are within the maximum permissible limit. Whereas in the case of calcium, though the value was found within desirable limit during the pre-monsoon, it exceeded the limit during the post-monsoon. The undesirable concentrations of nitrate, calcium and magnesium in the well water samples of Kattakambel, particularly in the post-monsoon period

can be attributed to the leaches and infiltration of these ions from the agricultural runoff or from carelessly disposed solid and sewage waste in the area.

The average values of electrical conductance (EC) recorded in the open well water samples varied from 0.1ms to 3.25ms in the pre-monsoon period and 0.1ms to 4ms in the post-monsoon period. The EC was found very high in OWW-1 of Kattakambel Grama Panchayat compared to OWW-2 of Veloor and OWW-3 of Chowannur during both the study periods. The higher EC in the well water samples of Kattakambel may be due to comparatively higher concentrations of dissolved solids such as nitrates, magnesium and chlorides and comparatively higher values of alkalinity and hardness. This interpretation in the study are in agreement with the observations of Sunitha et al. (2005) who find a higher level correlation of electrical conductance with total dissolved solids, alkalinity and hardness of water. The desirable pH range for natural drinking set by BIS is 6.5 to 8.5, however in the present study the pH of well water samples varied from 5.52 to 6.78 in the pre-monsoon and from 5.8 to 7.04 in the post-monsoon period. The highest pH value was recorded in the well water sample OWW-2 of Veloor and the lowest pH value was recorded in the OWW-1 of Kattakambel. The data presented in the Table-3 indicate that the pH of OWW-2 lies within the desirable limit whereas pH of OWW-1 and OWW-3 are not satisfying the BIS standard. The low pH values of OWW-1 and OWW-3 may be due to the leaching of organic acids and ions from organic matter or it can be attributed to the presence of dissolved carbon dioxide generated by bacteriological oxidation (Sawyer & McCarty 1967). Since there is a possibility for complex interactions between pH and many physicochemical parameters in the water body, it may damage water supply systems and therefore the pH may have an indirect effect on human health **(Araminiet al., 2009)**

Iron content up to 0.3mg/l is considered as desirable level for drinking water and a maximum permissible level is 1mg/l. The iron value in the present study varied from 0.25mg/l to 1.25mg/l in the pre-monsoon period and 0.23mg/l to 1.34mg/l in the post-monsoon period. The highest average value was recorded in the well water OWW-3 of Chowannur and the lowest value was recorded in the OWW-2 of Veloor. The iron concentration in OWW-1 exceeded the desirable level in the pre-monsoon while in the post-monsoon it exceeded the maximum permissible limit, whereas the OWW-3 sample exceeded the maximum permissible limit during both the periods. Well water sample OWW-2 of Veloor exhibited iron values which are well within the desirable level in both the study periods. The higher concentration of iron in the OWW-3 and OWW-1 can be attributed to the leaches from solid waste and sewage effluents (Oliver & Cosgrove, 1975). Accumulation of iron in the body can cause tissue damage (Hopps, 1972).

Total dissolved solids (TDS) in the analyzed water samples ranged from 122.5mg/l to 578mg/l and 112mg/l to 745mg/l respectively duringpre-monsoon and post-monsoon. Highest TDS values recorded in the OWW-1 sample in both the study season while the lowest values in the OWW-2 sample. The data presented in the Table-3 reveals, with the exception of well water sample OWW-1of Kattakambel, the TDS of other water samples are well within the desirable level whereas the former exceeded the desirable level but lies within the maximum permissible limit. Increased TDS value in the OWW-1 can be attributed to the comparatively higher concentration of dissolvedinorganic salts, organic matter and ions including calcium,magnesium, nitrates, chlorides and sulphates, which originate from sewage, agricultural leaches and waste water from industries.Concentration of TDS above 500mg/l may cause unpleasant taste to water and may cause corrosion or encrustation in water distribution systems (Tihansky, 1974). The dissolved oxygen (DO) content in the analyzed water samplesvaried from 1.8mg/l to 6.25mg/l in the pre-monsoon while it was 1.45mg/l to 6.3mg/l in the post-monsoon. The DO level of ≥5.0 is considered as desirable for natural drinking water. The highest DO content was recorded in the well water samples of Veloor while the lowest content in the water samples of Kattakambel. The data presented in the table 3 shows, with the exception of DO value in OWW-2 sample of Veloor, values of all other samples are not satisfying the BIS standard. The undesirable DO content in the well water samples OWW-1 and OWW3 can be attributed to higher BOD of these water bodies due to increased pollution by biodegradable compounds which require high oxygen demand (Osibanjo and Adie, 2007). Lower DO content in the water bodies may give bad odour due to anaerobic respiration of organic matter (Sallae, 1974). The values of biochemicaloxygen demand (BOD) obtained from

the well water samples in the study varied from 1.9mg/l to 6.7mg/l and 1.8mg/l to 7.2mg/l in the pre-monsoon and post-monsoon period respectively. The result presented in the Table-3 shows the BOD value of all the water samples exceeded the prescribed limit of ≤1.0 mg/l. The highest BOD value was recorded in the water sample OWW-1 of Kattakambel while the lowest value was recorded in the OWW-2 of Veloor. Higher values of BOD in OWW-1 and OWW-3 compared to OWW-2 clearly indicate more pollution and this may be attributed to the percolation of more polluted water loaded with biodegradable compounds. This caused increased requirement of oxygen by the living organisms in the water bodies to breakdown and utilize the organic matter, which results in higher BOD (Hawkes, 1963).

The detection and quantification of indicator bacteria is one of the important aspects to evaluate potability and sanitary conditions of water bodies. As per the guidelines of BIS (2012) and WHO (1996) with respect to the bacteriological standards that are to be maintained for drinking water, there should not be any coliform or fecal coliform bacteria detected per 100ml of the water. The results of the bacteriological analysis of open well water samples collected from the Grama Panchayats - Kattakambel (OWW-1), Veloor (OWW-2) and Chowannur (OWW-3) are shown in the Table-4.

Table 4: Bacteriological Properties of Open Well Water Samples Collected from Selected Gramapanchayat in the Thrissur District during the Pre-Monsoon and Post-Monsoon Season

Bacteriological Parameters	Study Area (GramaPanchayath) and season					
	Pre-monsoon			Post-monsoon		
	Kattakambel (OWW-1)	Veloor (OWW2)	Chowannur (OWW-3)	Kattakambel (OWW-1)	Veloor (OWW2)	Chowannur (OWW-3)
TC (CFU/ 100ml)	52.7 ±13.6	0.0±0.0	22.33±2.05	119.33±47.95	0.0±0.0	23.33±8.38
FC (CFU/ 100ml)	27±7.87	0.0±0.0	9.33±3.3	48.67±26.39	0.0±0.0	6.67±4.78
E.coli (CFU/ 100ml)	10.67±5.44	0.0±0.0	0.0±0.0	19.67±9.03	0.0±0.0	0.0±0.0

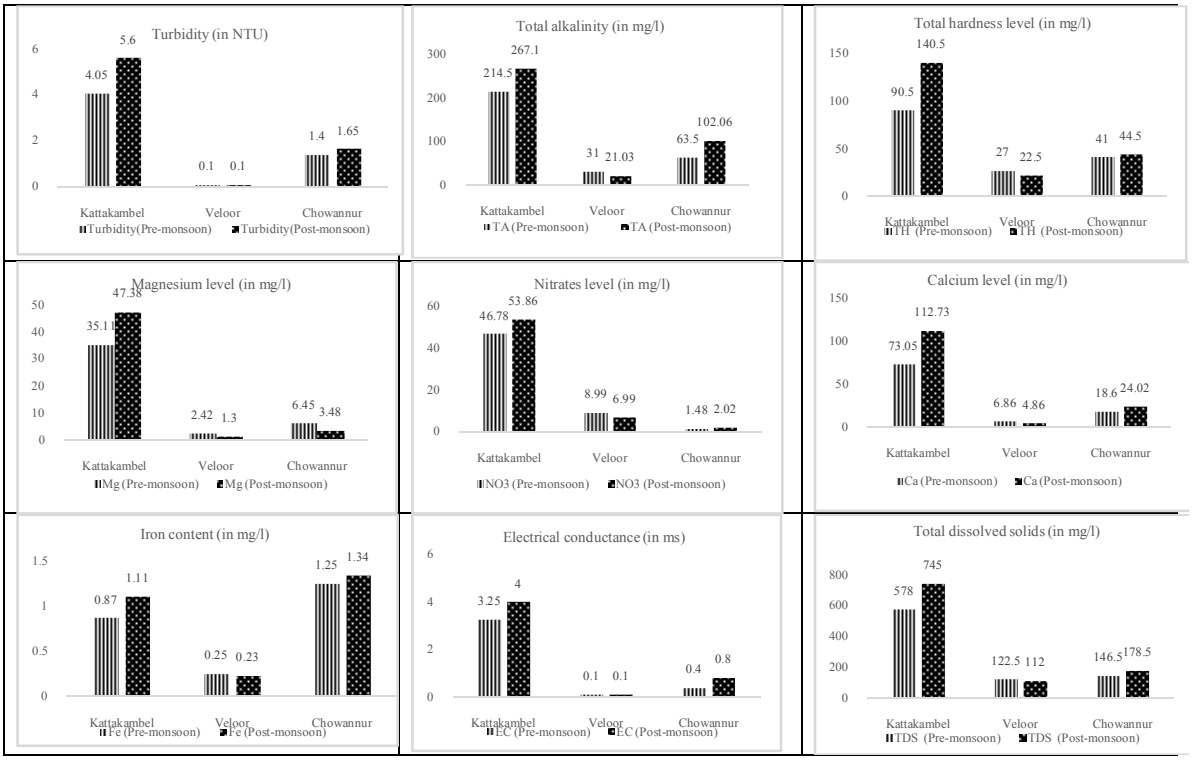
The presence of total coliform (TC) and faecal coliform (FC)were detected and their count recorded in both OWW-1 of Kattakambeland OWW-3 of ChowannurGramaPanchayath while the presence of Escherichia coli (EC) and their count was recorded only in the well water sample OWW-1. The bacterial indicators were not detected in the well water sample OWW-2 of Veloor Grama Panchayath. Highest TC and FC count was recorded in the well water sample of Kattakambel Grama Panchayath during both the study season and are 52.7CFU/100ml and 119.33 CFU/100ml respectively in the pre-monsoon and post-monsoon for TC and 27 CFU/100ml and 48.67 CFU/100ml respectively in the pre-monsoon and post-monsoon for FC. The E. coli count recorded in the OWW-1 sample was 10.67 CFU/100ml in the pre-monsoon and 19.67 CFU/100ml in the post-monsoon. The detection of E. coli in the well water sample OWW-1 is the clear indication of contamination most probably by human faecal matter, due to the leakages from septic tank or leaches from pit latrine system (Okonkoet al., 2008). The detection of faecal coliform but the absence of E. coliin the well water sample OWW-3 indicates fecal contamination but not necessarily due to human sewage but possibly due to leaches from cattle farming or due to bird's droppings.

The present study further analyzed the influence of seasonal variation on the physicochemical and bacteriological properties of well water samples in the selected Grama Panchayats. The data presented in the Table-3 and Figure-1 revealed that most of the physicochemical parameters of well water samples OWW-1 of Kattakambel and OWW-3 of Chowannur, with certain exceptions, tended to increase the values in the post-monsoon season compared to pre-monsoon. The exception includes the trend of DO in OWW-1 and magnesium in OWW-3 which showed a decrease in the post-monsoon. However in the well water

sample OWW-2 of Veloor, with certain exceptions, the values of most of the parameters tended to decrease in the post-monsoon. The exceptions include DO and pH which showed increased values while EC and turbidity did not show any change in the values due to seasonal variation. With respect to bacteriological parameters, with the exception of FC count in the OWW-3 during the post-monsoon season, all the parameters in OWW-1 and OWW-3 tended to increase over the pre-monsoon count, whereas the former showed a decreased count (figure 2).Comparatively higher count recorded in the bacteriological parameters during the post-monsoon season in the well water OWW-1 and OWW-3 can be attributed to the increased leaches and percolation of pollutants due to enhanced ground water level and poor filtering action of soil (Chitanand, 2008)

CONCLUSION

The study revealed that the selected open well water samples OWW-1 of Kattakambel and OWW-3 of Chowannur Grama Panchayats are not satisfying the drinking water quality standards prescribed by Bureau of Indian Standards while with respect to OWW-2 of Veloor, with an exception of slight variation in the values of BOD from the prescribed level, all physicochemical and bacteriological parameters are satisfactory and found safe for drinking purpose. Presence of faecalcoliform bacteria and undesirable levels of few or many physicochemical parameters identified in the OWW-1 and OWW-3 indicate severe health risk to those who use these water sources for drinking and other domestic purposes. The study suggests immediate remedial action on treating these water resources before consumption.



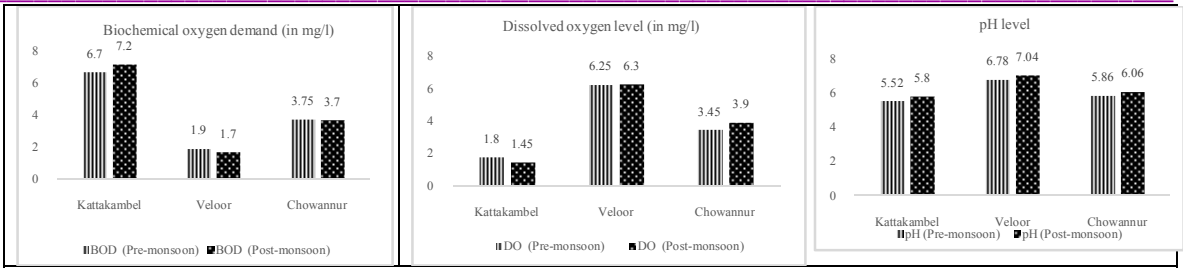


Figure 1: Seasonal Variation on the Physicochemical Parameters of Open Well Water in the selected Grama Panchayats

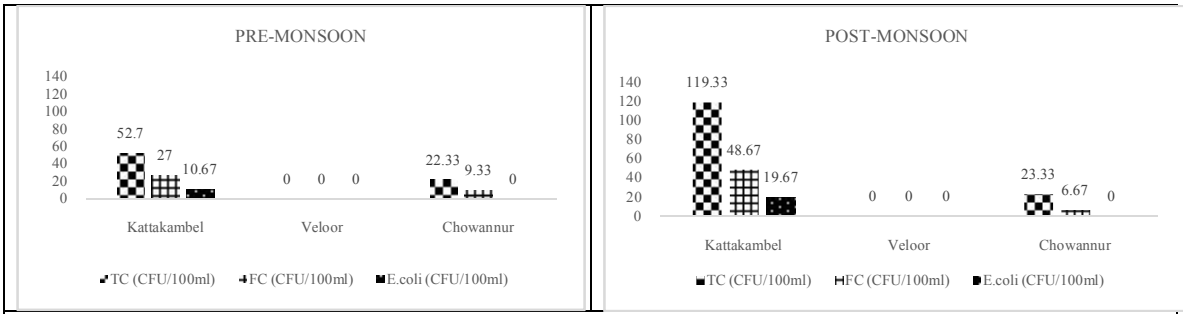


Figure 2: Seasonal Variation on the Bacteriological Parameters of Open Well Water in the selected Grama Panchayats

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