International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

Grade Card Method of Ground Water Health Evaluation of Mustoor Sub-Watershed Chikballapur Taluk Karnataka

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Abstract*: Ground water occurs commonly and is widely distributed and is the most reliable resource the quality of ground water needs to be monitored and preserved. In this study, as a part of the research work an attempt is made to assess the health of ground water in Mustoor sub-watershed. 11 Samples are selected from the influencing major villages and villages with surface waterbody in the sub watershed. A water grade card is an aid to educate and remind about the conditions of naturally available water resource around the users with the help of Water Quality Index method in comparison with Indian Standards IS 10500. Multi-metric indicators and indices aid to build a water grade card, in this study 11 samples of ground water are tested for eight selected Physico-chemical parameters (pH, turbidity, iron, fluoride, chloride, nitrate, total dissolved solids and total hardness) in March and October months, 2018 as Pre and Post Monsoon months. GWQI method helps in assigning the grades. It is intended for diverse users: like any individuals and institutions to policymakers and planners. The indicators collectively provide the overall health that is scored and is graded to report the condition or quality of the groundwater in the sub watershed in a better understanding way to the common people with the help of grades.

***Keywords*: Grade card; Score card; Water Quality; Water Quality Index; Ground Water Quality.**

I. INTRODUCTION

Water being an important element for existence of life, the concern about its quality and quantity cannot be ignored. The quantity of Surface water available is less and cannot meet the increasing demand. When the surface water is in danger, ground water is the alternative the world is dependent on. Surface water resources are exploited; hence it is not available in abundance at site where as ground water occurs commonly and is widely distributed and is the most reliable source. The quality of ground water needs to be monitored and preserved.

Quality Index of water (WQI) is the reflection of the rating of combined effect of various parameters of the water quality.

Revised Manuscript Received on November 30, 2019.
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The concept of quality index of water was first developed by Horton (1965). Brown, et. al., (1970) has developed further and the method of water quality index was further improved by Deininger Tozer (1975). Large number of data pertaining to the quality of water is calculated into a single number with the help of a mathematical equation. Water quality index communicates the information to diverse users: like any individuals and institutions to policymakers and planners; hence, water quality index method is proved to be an effective tool to determine the water quality. Geographical information system (GIS) and Remote Sensing (RS) has been a helpful tool that gives information about the quality of water and helps in preparation of user-friendly maps. Sajal Singh, et al. (2016) [1].

Water quality conditions are determined with the help of indices of water quality. WQI has been attempted by the researchers to develop quality index of water with the aggregation of five types of functions viz., arithmetic, multiplicative, geometric, harmonic and minimum average functions. Creating the water quality index needs to address the following: obtain the concentrations of individual indicators of water quality by tests and represent the values on a common scale by transforming the concentration measurements into sub index. Overall water quality index is to be obtained by aggregating the sub index values of individual concentrations, which represent the health of the water sample. Kosha A. Shah and Geeta S. Joshi (2017) [6].

Meeta Gupta et.al. (2017) [4], suggest the score card method of water quality evaluation in the watershed. After conduction of tests to determine the parameters like Ph, Turbidity, Total dissolved solids (TDS), Total Hardness, Chloride, Nitrate, Fluoride, and Iron. According to IS: 3025 (Part 11, 10, 16, 21, 32, 34, 60, 53) for ground water quality.

II. STUDY AREA AND SAMPLING

Mustoor Sub-watershed was taken as study area as it was treated under IWMP Programme. To check the Ground water quality Random sampling method was adopted for collecting the samples considering the major villages in the sub-watershed and were tested in laboratories. The tested samples were analysed parameter wise and GWQI is prepared for march and October 2018. And grades were allotted. Sampling Location map Fig. 1, WQI map for march and October are prepared using GIS & Remote sensing technique.

Groundwater quality tests are performed in March and October 2018. A total of 11 samples viz.,(GWS01-Mustoor), (GWS02-Harobande),(GWS03-Manjanabale),(GWS04-Gundlagurki),(GWS05-Marasanahalli),(GWS06-Kadadibbur),(GWS07-Dibbur), (GWS08-Gonachinnappana halli), (GWS09-Lingashettypura), (GWS10-Kavarnahalli), (GWS11-Guvvalakanahalli) and are tested for eight selected Physio-chemical parameters (Ph, turbidity, iron, fluoride, chloride, nitrate, total dissolved solids and total hardness)

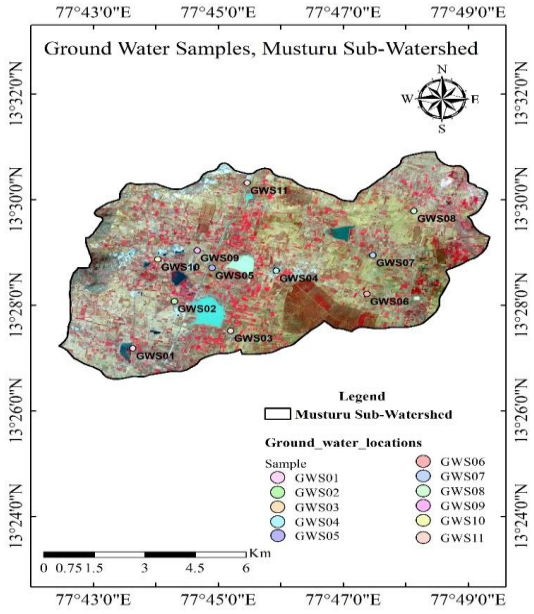

Fig. 1. Ground water samples Location Map

III. METHODOLOGY

The study area map was prepared using satellite image in GIS software. The sampling location was selected based on major influencing villages and villages having surface waterbody in the sub watershed.

Sampling area was finalized and parameters to be tested are finalized with the aid of literature survey. 11 samples were collected in the sub watershed in March and October month as pre and post months of monsoon season. All the collected samples were laboratory tested statistical analysis of obtained results was done.

The standards (Si) Adopted for WQI calculation and Specific Weights are assigned through literature survey. Ramakrishnaiah, C. R. et.al., (2009) [2], Bureau of Indian Standards IS 10500 (2012) [3], Meeta Gupta et.al. (2017) [4]. Standards and weights for Groundwater quality index adopted are in Table II.

The Indian standards of water quality IS 10500 (2012) [3] was adopted in the weighted arithmetic index method for determination of Ground water quality Index (GWQI). Table I, showcase the information of the scale rating from 0 – 300. The GWQI values are categorized as 5 classifications and accordingly grades are assigned and finally a Grade card is prepared. Fig. 2 represents Methodology flowchart.

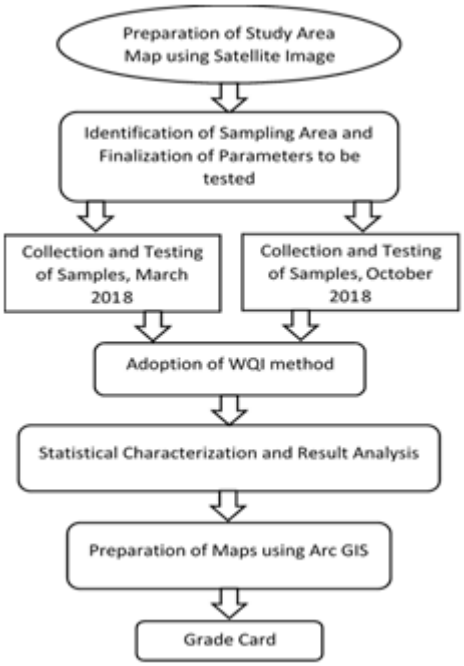

Fig. 2. Methodology Flowchart

Table I: Grades for Groundwater quality index

WQI Value	Classification	Quality of Water	Grade
Less than 50	1st	Excellent	A
Between 50 to 100	2nd	Good	B
Between 100 to 200	3rd	Poor	C
Between 200 to 300	4th	Very Poor	D
Greater than 300	5th	Unsuitable for Drinking	E
Source: Gupta, M., et al. (2017), https://doi.org/10.1016/j.iswcr.2017.10.001			

Table II: Standards and weights for quality Index of Groundwater

Parameters	Standards (Si)	Specific Weights (wi)	Relative Weights (Wi)
pH	8	4	0.14
Turbidity(NTU)	10	2	0.07
Iron(mg/L)	0.3	4	0.14
Fluoride(mg/L)	1.5	4	0.14
Chloride(mg/L)	250	3	0.11
Nitrate(mg/L)	45	5	0.18
Hardness(mg/L)	300	2	0.07
TDS(mg/L)	500	4	0.14
		∑wi=28	∑Wi=1

IV. RESULTS AND DISCUSSION

A. Test Results:

The Laboratory Experimented Test results obtained are tabulated in Table III and Table IV respectively.

Table III: Test Results Ground water samples, March 2018

Parameters	Units	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
pH		7.36	7.54	7.32	6.8	6.86	7.5	7.5	7.87	7.05	7.11	6.43
Turbidity	NTU	0.4	1.3	62	0.6	0.3	0.2	0.3	0.5	0.6	0.2	2.8
Iron	(mg/L)	0.1	0.1	1.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fluoride	(mg/L)	0.3	0.7	0.2	0.8	0.4	0.2	0.3	0.3	0.5	0.3	0.4
Chloride	(mg/L)	100	170	45	140	80	95	89	120	100	60	80
Nitrate	(mg/L)	2.9	4.9	2	6	3.1	1.8	1.9	3	3.2	1.5	2.3
Total hardness	(mg/L)	190	240	85	340	230	90	85	200	230	120	150
Total dissolved solids	(mg/L)	498	750	190	1046	482	250	250	524	548	300	370

Table IV: Test Results Ground water samples, October 2018

Parameters	Units	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
pH		7.62	6.53	8.21	7.17	7.56	7.1	6.55	8.33	7.37	6.94	6.59
Turbidity	NTU	1.2	1.1	16.9	1.6	1.5	9.6	4.8	1.2	3.9	6.7	0.8
Iron	(mg/L)	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Fluoride	(mg/L)	0.3	0.4	0.5	0.5	0.3	0.7	0.1	0.4	0.2	0.3	0.1
Chloride	(mg/L)	110	130	100	130	110	290	16	100	54	90	24
Nitrate	(mg/L)	2.5	4.5	5.8	4.4	3.1	10.2	0.8	3	2	2.3	1
Total hardness	(mg/L)	180	148	132	120	130	270	42	148	88	108	42
Total dissolved solids	(mg/L)	460	520	400	472	360	950	140	400	280	322	110

B. Statistical Characterization

Statistical Characterization of Ground water quality data sets for all the selected set of parameters for March 2018 and October 2018 are tabulated in table V and VI respectively.

Table V: Statistical Characterization of Ground water quality data sets, March 2018

Parameters	Units	Avg	Max	Min	SD	Median
pH		7.21	7.87	6.43	0.41	7.32
Turbidity	NTU	6.29	62	0.2	18.49	0.5
Iron	(mg/L)	0.24	1.6	0.1	0.45	0.1
Fluoride	(mg/L)	0.40	0.8	0.2	0.19	0.3
Chloride	(mg/L)	98.09	170	45	35.26	95
Nitrate	(mg/L)	2.96	6	1.5	1.38	2.9
Total hardness	(mg/L)	178.18	340	85	80.82	190
Total dissolved solids	(mg/L)	473.45	1046	190	251.81	482

Table VI: Statistical Characterization of Ground water quality data sets, October 2018

Parameters	Units	Avg	Max	Min	SD	Median
pH		7.27	8.33	6.53	0.62	7.17
Turbidity	NTU	4.48	16.90	0.80	4.99	1.60
Iron	(mg/L)	0.12	0.20	0.10	0.04	0.10
Fluoride	(mg/L)	0.35	0.70	0.10	0.18	0.30
Chloride	(mg/L)	104.91	290	16	72.72	100
Nitrate	(mg/L)	3.60	10.20	0.80	2.66	3
Total hardness	(mg/L)	128	270	42	63.67	130
Total dissolved solids	(mg/L)	401.27	950	110	223.48	400

C. Parameters Study

Parameter study, all the samples collected are represented in X axis and Respective Physico-Chemical value in Y axis in all the graphs of individual Physico-Chemical parameters

1. pH:

The acceptable range of pH in the drinking water as per Bureau of Indian Standards is between 6.5 to 8.5, if the water pH is not in the range high pH shows bitter or soda taste and low pH shows corrosive nature and metallic taste. In this study for all the 11 samples the observed pH range was from 6.43 to 7.87 in March 2018 and between 6.53 to 8.33 in October 2018. It is evident that the pH value is in range as per the BIS recommendations.

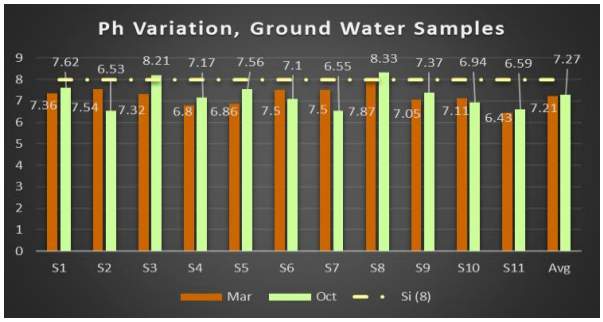

Fig. 3. Variation of pH

2. Turbidity:

The acceptable turbidity range for ground water is 10 Nephelometric Turbidity Units (NTU). It is observed that viruses, parasites and some pathogenic bacteria are associated with higher levels of turbidity. Health effects like headaches, diarrhea to name few can be faced. In this study the range of turbidity observed in March 2018 was 0.2 to 6.29 in 10 samples only in sample 3 the turbidity value is 62 NTU which is high and above the acceptable standard value. In October 2018 the range changed between 0.8 to 16.9 considering all 11 samples.

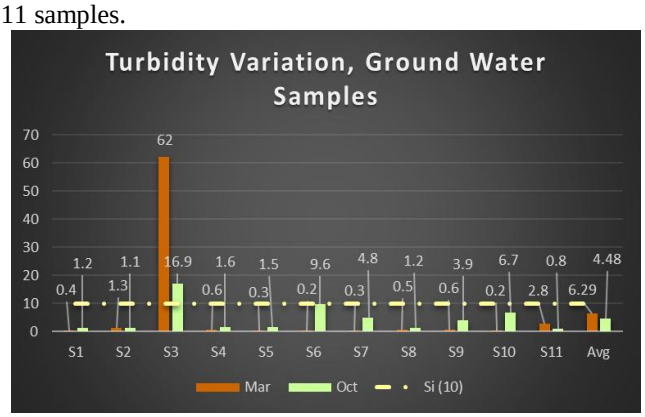

Fig. 4. Variation of Turbidity

3. Iron Fe:

The desirable iron value in drinking water is 0.3mg/l and acceptable up to 1mg/l. if the range exceeds it has adverse effects on water supply structures and domestic use it is also not acceptable for processing of food and beverages. In this study the range of iron content observed was 0.1 in 11 samples and sample number 3 has a value of 1.6 which is above acceptable range according to BIS. In the month of March 2018. The range of Iron observed in October 2018 is between 0.1 to 0.2

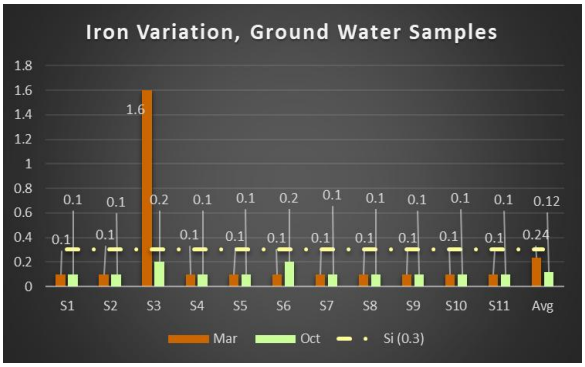

Fig. 5. Variation of Iron

4. Fluoride:

The desirable range of fluoride in water content is 0.6 and acceptable up to 1.5, water containing fluoride below 0.6 should be rejected since it causes dental caries. If the water contains above acceptable range, there is a high risk for bone damage, and it causes dental & skeletal fluoronish. The observed value of fluoride in 11 samples for March 20018 were between 0.2 to 0.8 and in October 2018 the range is from 0.1 to 0.7

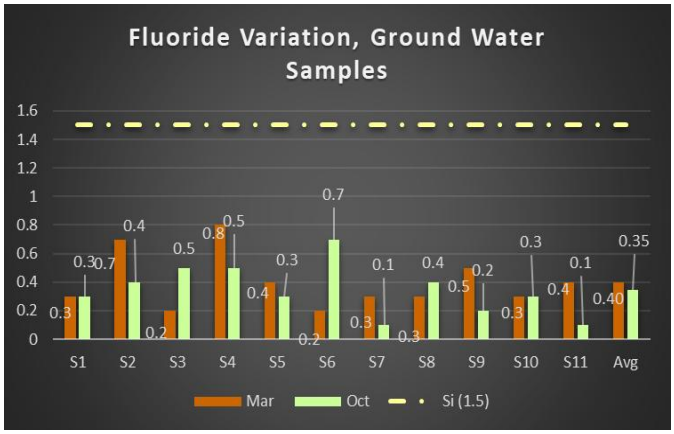

Fig. 6. Variation of Fluoride

5. Chloride:

The desirable limit of chloride concentration in the water sample is 200mg/l and acceptable to a range of 1000mg/l. if the limits are crossed on higher level there is a risk of High blood pressure, it also corrodes the appliances, fixtures and pipes, pitting and blackening of stainless steel also takes place and the water will have salty taste. In this study the minimum and maximum chloride concentration in water samples were found to be 45mg/l and 170mg/l which is well within the permissible limits according to BIS. It was observed a range of 16mg/l to 290mg/l in October 2018.

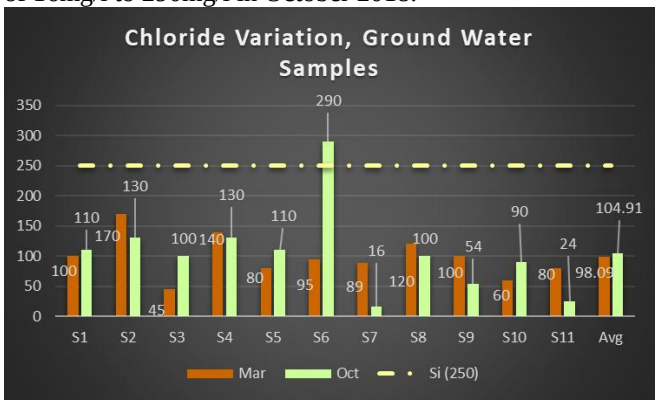

Fig. 7. Variation of Chloride

6. Nitrate:

The Desirable limit of nitrate is 45 mg/l and Permissible limit of 100 mg/lit. High nitrate value in drinking water may cause Methemoglobinemia or blue baby disease in infants. In this study all the samples have shown low nitrate levels ranging from 1.5mg/l to 6mg/l in March 2018 and 0.8mg/l to 10.2mg/l in October 2018.

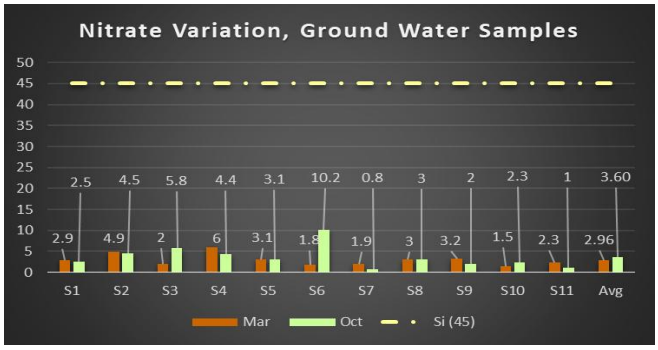

Fig. 8. Variation of Nitrate

7. Hardness:

The Desirable limit of Hardness is 300 mg/l and Permissible up to 600 mg/l. Effects observed may be scale formation in utensils and damage of hot water system, etc. the reason for hardness could be Dissolved calcium and magnesium from soil and aquifer minerals containing limestone or dolomite. In this study the observed values are in the range of 85mg/l to 340mg/l and 42mg/l to 270mg/l

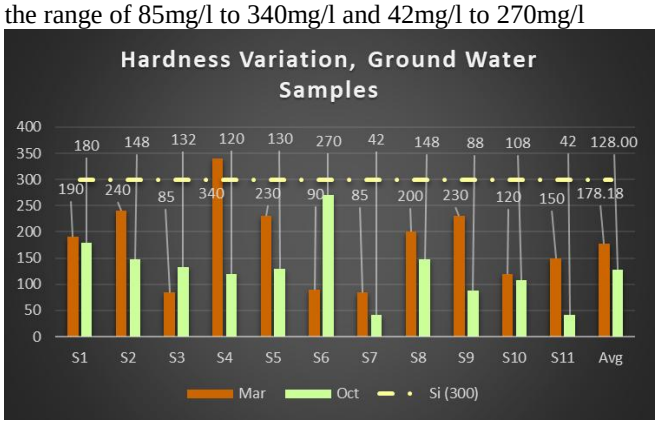

Fig. 9. Variation of Hardness

8. Total Dissolved Solids:

The Desirable limit of TDS is 500 mg/l and Permissible up to 2000 mg/l deviation from the acceptable range may result in Hardness, sediment, corrodes fittings and pipes, the taste of the water becomes bitter or salty. In this study the Total dissolved solids were in range of 190mg/l to 548mg/l. in March 2018 and only sample number 4 has TDS of 1046 mg/l. 110mg/l to 950mg/l in October 2018.

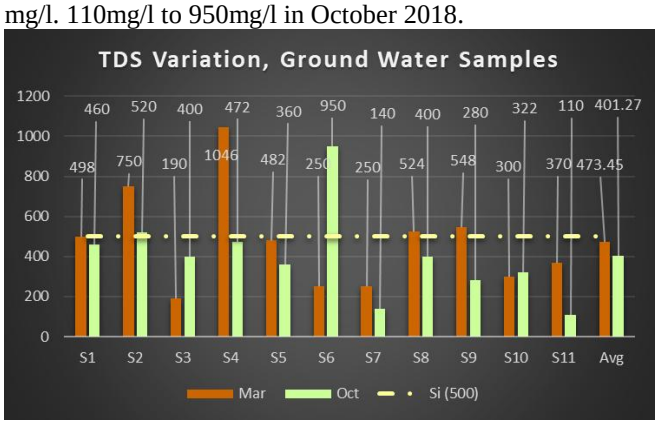

Fig. 10. Variation of Total Dissolved Solids

D. Water Quality Index

Water Quality Index was determined to all the eleven samples. Fig.11. shows graphical representation of WQI of all 11 samples in the month of March and Fig. 12 WQI in October 2019.

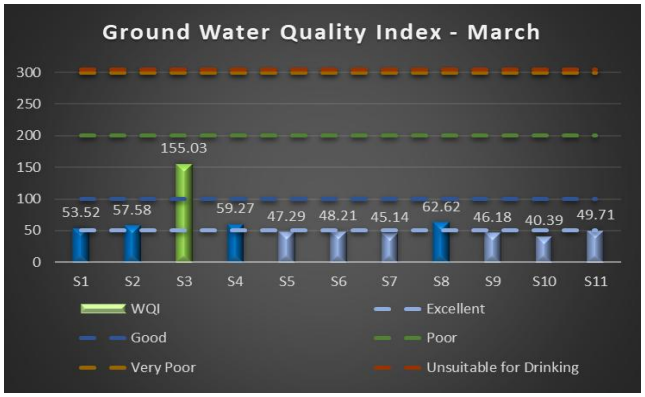

Fig. 11. Ground water Quality Index Graph, March 2018

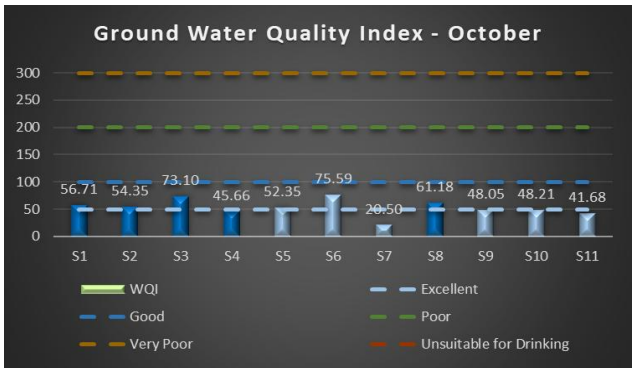

Fig. 12. Ground water Quality Index Graph, October 2018

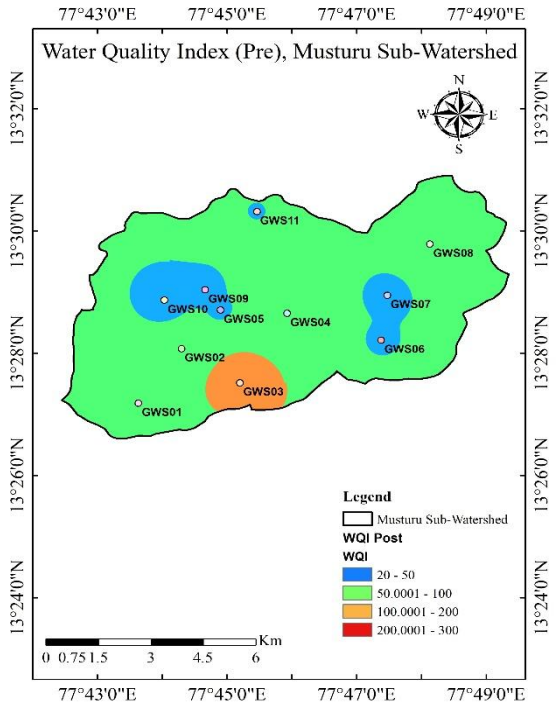

Fig. 13. Ground water Quality Index map, March 2018

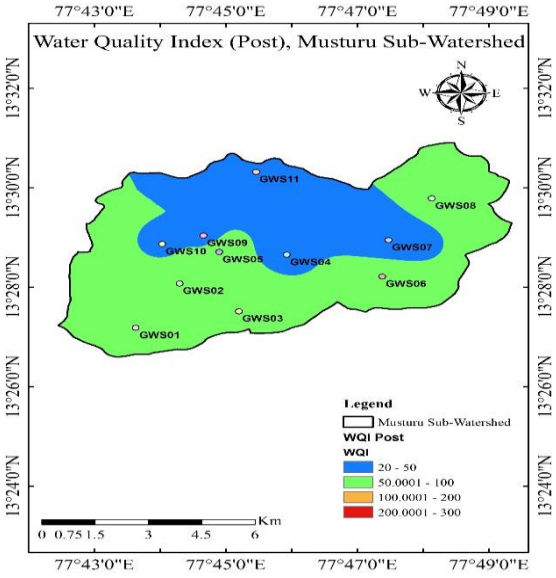

Fig. 14. Ground water Quality Index map, October 2018

It is evident from the Fig.13 and 14 GWQI maps, six borewells scored A (WQI <50), four borewells B (50< and<100) and one C (100<WQI <200) in the month of March 2018. Five borewells scored A (WQI <50), six borewells scored B (50<WQI <100) in October 2018.

V. CONCLUSION

The ground water quality tests were carried out in the Mustoor sub-watershed. The statistical analysis of ground water quality in the region was done from the test results of 8 parameters and WQI was calculated, it is observed that the sample number 3 received "C" Grade i.e., GWS3 (from Manjanabale village) representing it to be of poor-quality. Almost all the parameters were in range making the water fit for drinking and other domestic and agriculture purpose. The sample number 3 from Manjanabale village has shown poor water quality but, it can also be used at times of need. Table VII represents Groundwater health Grade card.

Table VII: Ground water health Grade Card

		Mar-18		Oct-18	
Sample No	**Location**	**WQI**	**Grade**	**WQI**	**Grade**
GWS01	Mustoor	53.52	B	56.71	B
GWS02	Harobande	57.58	B	54.35	B
GWS03	Manjanabale	155.03	C	73.10	B
GWS04	Gundlagurki	59.27	B	45.66	A
GWS05	Marasanahalli	47.29	A	52.35	B
GWS06	Kada dibbur	48.21	A	75.59	B
GWS07	Dibbur	45.14	A	20.50	A
GWS08	Gonachinnappana halli	62.62	B	61.18	B
GWS09	Lingashettypura	46.18	A	48.05	A
GWS10	Kavarnahalli	40.39	A	48.21	A
GWS11	Guvvalakanahalli	49.71	A	41.68	A

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He was honored with Life time Achievement National Awardin the name of Dr. A. P. J. Abdul Kalam in 2018 February 24th (International Institute for Social and Economic Reforms, Bangalore) and was also honored as Best Director on 5th July 2018 (World Education Congress)

He has guided 3 Ph.D.'s and 6 are under guidance. The number of International & National Journal papers are more than 30.