# WATER QUALITY INDEX OF GROUNDWATER OF KARHA RIVER BASIN AREA, BARAMATI, INDIA

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## ABSTRACT

Assessment of groundwater in Karha river basin area Baramati, Maharashtra, India was completed in two different seasons pre-monsoon (summer) 2018 and post-monsoon (winter) 2018 by collecting seventeen groundwater samples. The study of water quality index in karha river basin area has particular importance because of geological variations. The various physicochemical parameters such as pH, EC, $Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$, Total dissolved solids, $HCO_3^-$, $Cl^-$, $SO_4^{2-}$, $NO_3^-$, $F^-$, $PO_4^{2-}$, DO and BOD were determined using standard procedures of APHA. Six parameters namely pH, TDS, Phosphates, Nitrates, Dissolved Oxygen and Biochemical Oxygen Demand were considered to compute Water Quality Index based on National Sanitation Foundation (NSF - WQI). WQI is an excellent management and general administrative tool in communicating water quality information. NSF - WQI calculator was used to calculate the water Quality Index. Our findings highlighted the deterioration of water quality in certain parts of study area because of arid to semi-arid conditions. According to NSF - WQI ranking 59 – 65 % water samples were good to excellent quality for drinking purpose, 18 – 24 % water samples were medium quality while 18 % samples were bad and it was not suitable for drinking purpose. They may be used for drinking purpose after suitable treatment.

## 1. Introduction

Groundwater is one of the resource available for drinking purpose in exclusively arid and semi-arid regions of Karha river basin area. Due to the increased urbanization and industrialization surface and groundwater pollution has become a crucial problem [1]. The composition of groundwater depends on the natural and anthropogenic processes which can alter these systems by contaminating them or modifying the hydrological cycle [2-5]. Globally, 65% of groundwater is used for drinking purposes, 20% for irrigation and livestock, and 15% for industry and mining [6-7], and approximately one-third of the world's population depends only on groundwater for drinking purposes [8-9]. It is necessary to obtain precise and appropriate information to observe the quality of water resources and the development of some useful tools to keep watch on the quality of such priceless water resources to retain their excellence for various beneficial uses [10-14].

Water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programmes (15-21]. The objective of a water quality index is to turn multifaceted water quality data into simple information that is comprehensible and usable by the public [22]. Water quality index (WQI) is defined as a rating reflecting the composite influence of different water quality parameters. Horton [23] has firstly used the concept of WQI, which was further developed by Brown, Mc Clelland, Deininger, and Tozer [24] and improved by Deininger (Scottish Development Department, 1975). It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics [25]. WQI is a mathematical equation used to transform large number of water quality data into a single number. WQI is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy-makers [26].

Water quality index provide information on a rating scale from zero to hundred. Higher value of NSF-WQI indicates excellent quality of water and lower value shows poor water quality [27]. The present study aims at the assessment of the water quality index of groundwater of Karha river basin area Baramati, India by the National Sanitation Foundation Water Quality Index (NSF-WQI). The scoring system is determined based on the parameters of water quality are major temperature, dissolved solids (TDS), turbidity, dissolved oxygen (DO), pH, BOD, $NO_3$, $PO_4$, and fecal coli [28-31]. In this study mainly pH, total dissolve solids, nitrate, phosphate, DO, BOD were considered to calculate WQI.

## 2. Material and Methods

### 2.1 Study area:

Baramati Tahsil belongs to western part of Maharashtra. It belongs to Pune division. It is located 100 km towards east from district headquarters Pune. 240 km from state capital Mumbai towards east. Baramati Tehsil has its head quarter at Baramati town. Baramati Tehsil lies between 18º04´ to 18°32´ north latitudes and 74° 26´to 74° 69´ east longitudes (Figure 1). It is located at altitude of 550 meters above means sea level [32].


**Figure 1: Location map of the study area**

### 2.2 Sampling sites:

Ground water samples from different seventeen locations of karha River basin area were selected randomly and by considering the topography of the study area (Figure 1).

### 2.3 Sample Collection:

Water samples from the selected sites were collected in a good quality polyethylene bottle of one-litre capacity during the period of pre-monsoon (PRM) summer 2018 and post-monsoon (POM) winter 2018 seasons. Seventeen groundwater samples (W1- W17) from Karha River basin area were selected for collection of groundwater samples.

### 2.4 Physico-chemical analysis:

Physico-chemical parameters like pH, EC, TDS, $Ca^{2+}$, $Mg^{2+}$, $Cl^{-}$, $CO_3^{2-}$, $HCO_3^{-}$, $SO_4^{2-}$, $Na^{+}$, $K^{+}$, $NO_3^{-}$, $PO_4^{3-}$, DO, BOD etc. were analyzed in the laboratory by using standard methods recommended by APHA. Various physical parameters like pH, EC, and TDS were determined within two hours with the help of digital portable pH meter and conductivity meter in the laboratory. DO is fixed at the sampling site and estimated immediately in the laboratory. BOD is estimated after five days incubation. Calcium ($Ca^{2+}$), Magnesium ($Mg^{2+}$), Chloride ($Cl^{-}$), Carbonate ($CO_3^{2-}$), Bicarbonate ($HCO_3^{-}$) and Sulphate ($SO_4^{2-}$) were determined by volumetric titration methods; while Sodium ($Na^{+}$) and Potassium ($K^{+}$) by Flame photometry and phosphate is estimated by spectrophometrically as recommended by APHA [33]. The respective values for these parameters are reported in table 3 and table 4. Results obtained from analysis were calculated by using Water Quality Factors and parameters Weights in NSF-WQI (Table 1) and compared with NSF water quality ranking (Table 2).

### 2.5 National Sanitation Foundation Water Quality Index (NSF-WQI)

NSF-WQI is an excellent management and general administrative tool in communicating water quality information. This index has been widely field tested and applied to data from a number of different geographical areas all over the world in order to calculate Water Quality Index (WQI) of various water bodies critical pollution parameters were considered [34]. The mathematical expression for NSF WQI is given by

$$\text{NSF WQI} = \sum_{i=1}^{p} W_i I_i$$

Where-
$I_i$ is the sub-index for i[th] water quality Parameters
$W_i$ is the weight (in terms of importance) associated with i[th] water quality parameter
p is the number of water quality parameters
NSF Standard curve for conversion to Water Quality Index is given in figure 2. NSF-WQI of Karha river basin area is depicted in Figure 3. The Water Quality Factors and Weights are given in Table 1. Water quality factor weightage were used to calculate the water quality index of groundwater samples. The NSF water quality index ranking is given in table 2. The WQI calculated and compared with water quality ranking. The water quality obtained from this is given in table 3 and 4.

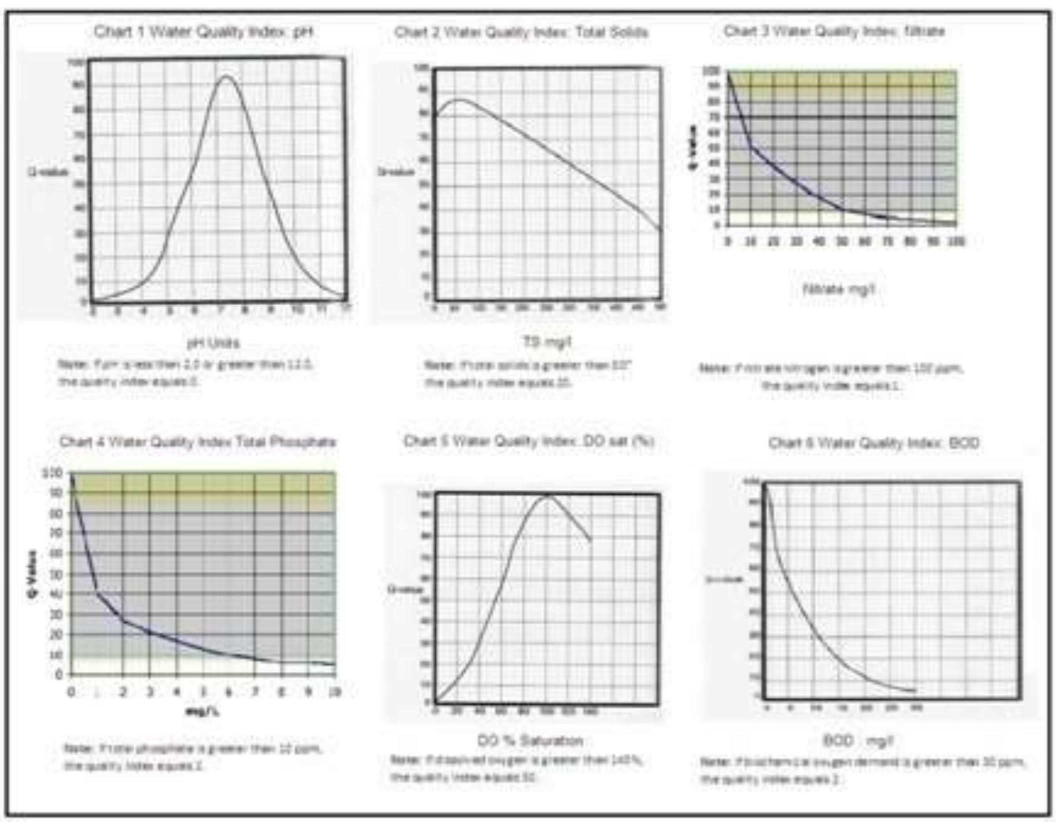


**Figure 2: NSF Standard curve for conversion to Water Quality Index**

**Table-1: Water Quality Factors and parameters Weights in NSF-WQI**

| Factor | Weight |
|---|---|
| Dissolved oxygen | 0.17 |
| Fecal coliform | 0.16 |
| pH | 0.11 |
| Biochemical oxygen demand | 0.11 |
| Temperature change | 0.1 |
| Total phosphate | 0.1 |
| Nitrates | 0.1 |
| Turbidity | 0.08 |
| Total solids | 0.07 |

**Table-2: NSF water quality index ranking**

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

## 3. Results and Discussion

Physico-chemical parameters of ground water samples such as pH, TDS, Phosphates, Nitrates, Dissolved Oxygen and Biochemical Oxygen Demand from different locations in pre-monsoon and post-monsoon season have been considered to calculate the NSF – WQI. The calculated NSF - WQI values are given in Table 3 and 4. The National Sanitation Foundation Water Quality Index calculator is used to calculate the water Quality Index of water samples (Figure 2).

**Table 3: Physico-chemical data of the ground water from Karha River basin area Summer (Pre monsoon) 2018 and WQI**

| Sr. No. | pH | TDS | $NO_3^-$ | $PO_4^{3-}$ | DO | BOD | WQI | Water Quality |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | mg/l | mg/l | % | mg/l | | |
| W1 | 7.71 | 371 | 47 | 4.35 | 88 | 2.60 | 47 | Bad |
| W2 | 8.04 | 371 | 46 | 6.25 | 75 | 2.20 | 45 | Bad |
| W3 | 8.50 | 1100 | 47 | 3.78 | 79 | 2.25 | 97 | Excellent |
| W4 | 7.56 | 1088 | 36 | 5.27 | 73 | 2.20 | 94 | Excellent |
| W5 | 6.75 | 950 | 43 | 4.85 | 92 | 0.44 | 88 | Good |
| W6 | 7.10 | 1025 | 47 | 5.20 | 68 | 0.78 | 89 | Good |
| W7 | 7.16 | 890 | 51 | 3.10 | 77 | 1.45 | 82 | Good |
| W8 | 7.49 | 736 | 36 | 3.80 | 68 | 1.80 | 68 | Medium |
| W9 | 7.25 | 955 | 65 | 2.70 | 78 | 1.40 | 88 | Good |
| W10 | 7.00 | 1025 | 70 | 2.90 | 68 | 1.40 | 92 | Excellent |
| W11 | 7.58 | 512 | 55 | 7.50 | 70 | 1.30 | 55 | Medium |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| W12 | 8.38 | 890 | 41 | 3.81 | 72 | 1.75 | 80 | Good |
| W13 | 7.30 | 864 | 48 | 7.50 | 81 | 2.48 | 81 | Good |
| W14 | 8.11 | 736 | 45 | 8.10 | 78 | 1.70 | 71 | Good |
| W15 | 7.40 | 314 | 50 | 3.30 | 77 | 0.90 | 41 | Bad |
| W16 | 8.19 | 467 | 71 | 6.20 | 85 | 2.60 | 56 | Medium |
| W17 | 7.76 | 582 | 68 | 7.43 | 65 | 1.40 | 60 | Medium |
| Avg | 7.60 | 757.41 | 50.94 | 5.06 | 76.12 | 1.69 | 73 | |
| Max | 8.50 | 1100.00 | 71.00 | 8.10 | 92.00 | 2.60 | 97 | |
| Min | 6.75 | 314.00 | 36.00 | 2.70 | 65.00 | 0.44 | 41 | |
| Med | 7.56 | 864.00 | 47.00 | 4.85 | 77.00 | 1.70 | 80 | |
| SD | ± 0.50 | ± 269.72 | ± 11.17 | ± 1.80 | ± 7.50 | ± 0.64 | ± 19 | |

**Table 4: Physico-chemical data of the ground water from Karha River basin area Winter (Post monsoon) 2018 and WQI**

| Sr. No. | pH | TDS | $NO_3^-$ | $PO_4^{3-}$ | DO | BOD | WQI | Water Quality |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | mg/l | mg/l | % | mg/l | | |
| W1 | 7.9 | 326 | 25 | 4.15 | 92 | 2.55 | 43 | Bad |
| W2 | 8.3 | 358 | 36 | 6.87 | 78 | 2.10 | 44 | Bad |
| W3 | 8.6 | 1120 | 27 | 3.28 | 82 | 2.15 | 97 | Excellent |
| W4 | 7.8 | 1037 | 28 | 5.84 | 78 | 2.30 | 90 | Excellent |
| W5 | 6.5 | 895 | 25 | 4.25 | 93 | 1.14 | 82 | Good |
| W6 | 7.3 | 975 | 35 | 5.85 | 75 | 0.58 | 86 | Good |
| W7 | 7.4 | 1024 | 37 | 3.59 | 79 | 1.25 | 90 | Excellent |
| W8 | 7.3 | 819 | 25 | 4.12 | 69 | 1.60 | 73 | Good |
| W9 | 7.1 | 875 | 35 | 3.20 | 77 | 1.25 | 79 | Good |
| W10 | 7.4 | 960 | 22 | 3.24 | 72 | 1.25 | 83 | Good |
| W11 | 7.4 | 579 | 26 | 6.95 | 69 | 1.38 | 57 | Medium |
| W12 | 8.2 | 1050 | 45 | 4.54 | 74 | 1.95 | 92 | Excellent |
| W13 | 7.5 | 838 | 44 | 6.85 | 72 | 2.28 | 77 | Good |
| W14 | 8.3 | 707 | 50 | 8.18 | 78 | 1.40 | 70 | Good |
| W15 | 7.1 | 390 | 42 | 3.45 | 72 | 0.70 | 45 | Bad |
| W16 | 8.1 | 506 | 47 | 6.80 | 88 | 2.45 | 57 | Medium |
| W17 | 7.6 | 621 | 52 | 7.75 | 72 | 1.20 | 63 | Medium |
| Avg | 7.64 | 769.41 | 35.35 | 5.23 | 77.65 | 1.62 | 72 | |
| Max | 8.60 | 1120.00 | 52.00 | 8.18 | 93.00 | 2.55 | 97 | |
| Min | 6.50 | 326.00 | 22.00 | 3.20 | 69.00 | 0.58 | 43 | |
| Med | 7.50 | 838.00 | 35.00 | 4.54 | 77.00 | 1.40 | 77 | |
| SD | ± 0.54 | ± 261.26 | ± 9.85 | ± 1.73 | ± 7.36 | ± 0.61 | ± 18 | |

### 3.1 pH

The pH of groundwater reflects the balance between dissolved carbon dioxide from the atmosphere and biological activity. In general, it is related to the dissolved carbonates and bicarbonates, silicates, borates, fluorides and other salts in dissociated form. Most groundwater has a pH range of 6 to 8.5 [35]. The pH values of groundwater in summer 2018 ranges from 6.75 to 8.50 having average 7.60. Standard deviation in pH was ± 0.450 while median of the data in this season is 7.56. The pH values of groundwater in winter 2018 ranges from 6.50 to 8.60 having average 7.64. Standard deviation in pH was ± 0.54 while median of the data in this season is 7.50.

### 3.2 Total dissolved solids (TDS)

Seasonal and spatial variations were observed in the total dissolved solid present in the groundwater samples collected from study area. The results of total dissolved solids (TDS) for ground water is shown in Table 3 and 4, these results were ranging between 314 to 1100 mg/l with standard deviation of ± 270 while median was 864 in summer 2018. In the winter season TDS ranges from 326 to 1120 with standard deviation of ± 261 while median was 838. Study area is draught prone and less rain fall area. In this area dilution of water is less due to scarcity of water, groundwater shows higher amount of salt concentration in that area. Raja and Venkatesan [36] assessed the groundwater pollution and its impact in and around Punnam area of Karur District, Tamilnadu, India. They observed the range of TDS in the area was minimum 925 mg/l to maximum 3020 mg/l.

### 3.3 Nitrate

Nitrate concentration of groundwater of study area in summer 2018 ranges from 36 to 71 mg/l having average 50.94 mg/l and deviation in nitrate concentration was found to be ± 11.17. In winter 2018 nitrate varies from 22 to 52 mg/l having average 35.35 mg/l. Standard deviation was ± 9.85 while median of the data in this season is 35.

According to the Ministry of drinking water and sanitation data report, the nitrate concentration in most of the villages of Baramati tahsil was higher than permissible limit (45 mg/l) [37]. Higher concentration of nitrate is attributed to the nitrogen excretion by cattle in the farm (i.e. animal wastes) and dairies where large number of buffalo and cows are housed in relatively small areas. Excreta of these animals get accumulated and is leached by rainfall and other water sources causing high nitrate pollution of water. The extent of such groundwater pollution depends on bio-degradation, soil and rock strata characteristics through which percolation takes place. Thus, nitrate pollution in the study area is combined effect of agricultural activity and animal wastes.

Most humans over one year of age have the ability to rapidly convert methemoglobin back to oxyhemoglobin; hence, the total amount of methemoglobin within red blood cells remains low instead of relatively high levels of nitrate/nitrite uptake. However, in infants under six months of age, the enzyme systems for reducing methemoglobin to oxyhemoglobin are incompletely developed and methemoglobinemia can occur. Adults can tolerate higher levels of nitrate-nitrogen with little or no documented adverse health effects and may be able to drink water with nitrate nitrogen concentrations considerably greater than 10 mg/l level with no acute toxicity effects [38].

### 3.4 Phosphate

Phosphate were added in groundwater from detergents in liquid waste and pesticides used in agricultural practices. Each phosphate compound is present in dissolved form, suspended or bound in the cells of organisms in water [39]. The phosphate values of groundwater in summer 2018 ranges from 2.70 to 8.10 mg/l having average 5.06. Standard deviation in phosphate was ± 1.80 while median of the data in this season is 4.85. The phosphate values of groundwater in winter 2018 ranges from 3.20 to 8.18 having average 5.23. Standard deviation in phosphate was ± 1.73 while median of the data in this season is 4.54.

### 3.5 Dissolved oxygen (DO)

Dissolved oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the waters. Its presence is essential to maintain the higher forms of biological life in the water; and the effects of a waste discharge in a water body are largely determined by the oxygen balance of the system. Water with oxygen content above 5 mg/l will support desirable form of aquatic life while water with less than 2 mg/l oxygen will support mainly bacteria, fungi and other microorganisms [40].

McNeil and Closs [41] explained in his study, dissolved oxygen values also show spatial and seasonal changes and is affected by human activities. The amount of dissolved oxygen (DO) present in the groundwater samples of study area varies from 65 to 92 % having average 76 %. Standard deviation in DO was ± 7.5 while median of the data in this season is 77. The DO values of groundwater in winter 2018 ranges from 69 to 93 % having average 77.65 %. Standard deviation in DO was ± 7.36 while median of the data in this season is 77.

### 3.6 Biological oxygen demand (BOD)

Agbaire and Oyibo [42] explained, BOD is a good indicator of the extent of organic pollution. For any water quality assessment, it is important to know the amount of organic matter present in the natural water and that the quantity of oxygen required for its stabilization. The BOD test is also useful in stream pollution control management and in evaluating the self-purification capacities of streams which serves as a measure to assess the quality of wastes which can be safely assimilated by the stream.

The amount of biological oxygen demand (BOD) present in the groundwater samples of study area varies from 0.44 to 2.60 mg/l having average 1.69 mg/l. Standard deviation in BOD was ± 0.64 while median of the data in this season is 1.70. The BOD values of groundwater in winter 2018 ranges from 0.58 to 2.55 mg/l having average 1.62 mg/l. Standard deviation in BOD was ± 0.61 while median of the data in this season is 1.40.

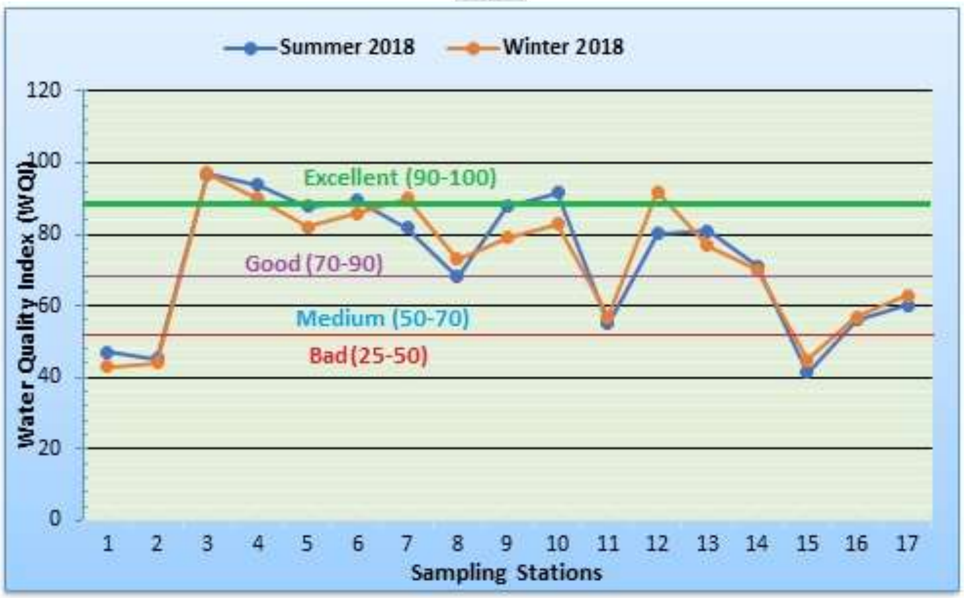


**Fig.-3: WQI for various ground water sampling location of the study area**

Graphical presentation of WQI in summer and winter seasons in study area represents the quality of water effectively (Figure 3).

### 3.7 Water Quality Index (NSF- WQI)

The classification criteria standards based on NSF - WQI are given in Table 2. According to the NSF – WQI classification of water quality, the quality of groundwater in 18 % samples were "Bad" and fall under category "D". 18-24 % groundwater samples were medium quality, 40 % groundwater samples were good category and 18-24 % groundwater samples were excellent quality (Figure 4). The values of WQI showed significant changes between different sampling locations and the analogous trend of seasonal variation.

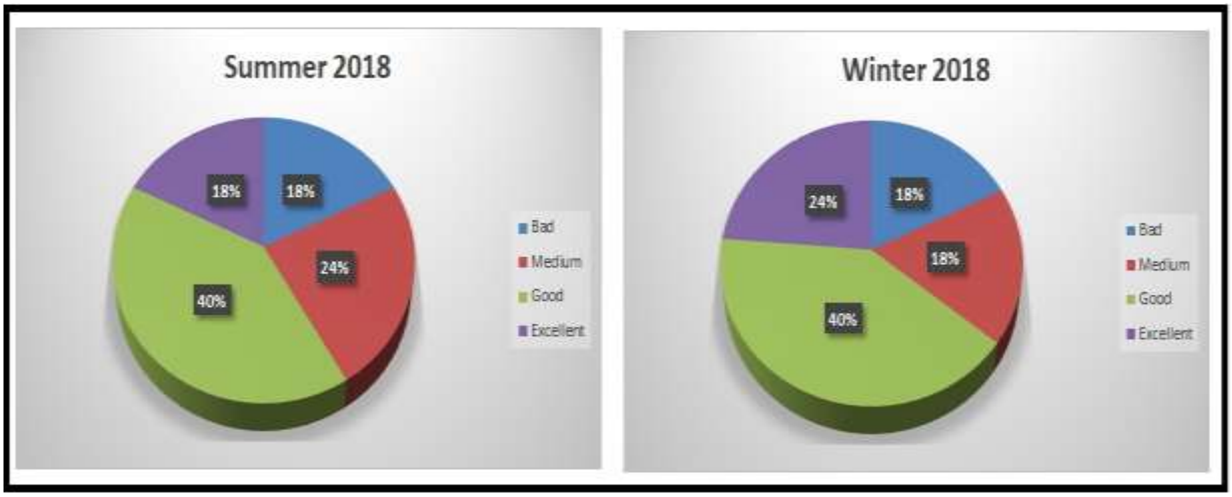


**Fig.-4: WQI Categories of samples (%) in various seasons**

## 4. Conclusion

Groundwater quality in the Karha river basin area has been analyzed. It is observed that (18 %) water samples are "Bad" and fall under category "D". 18-24 % groundwater samples were medium quality, 40 % groundwater samples were good category and 18-24 % groundwater samples were excellent quality. The overall groundwater quality of the study area is suitable for drinking purpose [43]. The ground water quality does not show any regional trend in any direction. It is recommended that the ground water may be used for drinking purpose after suitable treatment in certain areas.

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