# Seasonal Variations in Physico- Chemical Characteristics of Devarabelakere Reservoir in Karnataka, India and Its Suitability for Irrigation

## Chetana Madhusudan Prabhu[1] and K. Krishne Gowda[2]

[1]M. Tech Student, Civil Engineering, University of BDT College of Engineering, Davanagere, Karnataka, India
[2]Professor, Civil Engineering, University of BDT College of Engineering Davanagere, Karnataka, India

---***---

**Abstract -** *Irrigation plays an important role in coming days in feeding the increasing world population and also it has been a main contributor to the increase of national and world food supplies. At a large scale, irrigated agriculture utilizes about 70% of the available fresh water resources, in which about 80% in arid and semi-arid regions. For the use of irrigation purpose, water is diverted from the reservoir and the return flow water adds with the natural flow in the stream. Diversion of streams in many areas over a stretch, degrades the quality of the stream water in downward areas. Hence the study of surface and return flow water quality study for the irrigation purposes plays a major role. The study is carried out on the Devarabelakere reservoir, which is situated at downstream of the Bhadra Reservoir in Harihara Taluk in Davangere District of Karnataka State, India. Water sampling has been done in pre monsoon season and post monsoon season. Surface water quality analysis has been made to reservoir water, canal water, return flow water and stream water. In this study, different physico- chemical characteristics of water were analysed and important parameters were taken to determine the WQI of Devarabelekere Reservoir with the help of standards recommended by the WHO. And Weighted Arithmetic Index method is used for the calculation. According to WQI, results obtained as that the Devarabelakere reservoir water is suitable for irrigation purposes in both post monsoon and pre monsoon season.*

***Key Words*: Irrigation water quality, Return Flow, Salinity, Water quality Index.

## 1.INTRODUCTION

Irrigation plays a important role in India's agrarian strategy, although the improper use of water has damaged the soil and hampered the productivity. Water used for agricultural purpose is also competing with other demands mainly urbanization and changing lifestyles, resulting in increased water demand. Agriculture is affected by the any type of the water stress, which will indirectly affect the Indian Food security. Due to this employment is also at trouble since nearly 60% of Indians income depends on agriculture. Therefore, it is sure that the issue of water for agriculture to feed India's people is an additional key water security challenge[1].

The most part of the world overcoming with a important problem regarding the increasing population day by day and these are the areas where the minimum amount of extra land is available for the agricultural purposes. Arid and Semi-arid regions are mainly differentiated by its climate or weather, with no or insufficient rainfall to carry out agricultural activities. In arid and semi-arid regions, for cultivating crops, irrigation with the help of surface and groundwater is inevitable. Renewable water resources is utilized in a efficient and productive way is important for the sustainable agricultural production and rural regeneration in arid and semi-arid zones. The economic, climatic and environmental factors in this semi-arid regions necessitate systematic and rational resource management as a means of averting water crises potential. In these types areas, increased food production must obtained from more amount of intensive farming with maximum yields. Because of this, there is a important need to maximize the productivity of such lands. Rising in the groundwater tables and increased in the salinity in the groundwater mainly affects the agricultural production.

Present day technology is not enough to evaluate the quality of irrigation return flow. The major problem occurs when making long-range projections on quality of water in receiving stream due to the irrigation projects. And also problem due to the development of new irrigation projects, mainly which includes lands which are not previously irrigated. Hence the study of water and return flow water quality study for the irrigation purposes plays a major role in the arid and semi-arid regions.

### 1.1.    Study Area:

Devarabelakere pickup is constructed at downstream of the Bhadra Reservoir at a distance of 136.00 Km. The total catchment area of this sub-project is 2106.90sq. Km. of which 1338.90 sq.Km. is intercepted catchment, and the independent catchment is 768.00sq. Km. The Inflow in to the Devarabelakere pickup was not recorded. The catchment area is good and in addition seepage/surplus water from the command area of the Malebennur branch canal and Harihar branch canal of Davangere branch canal of Bhadra Right Bank Canal is adequate to meet the needs of the Devarabelakere pickup command. The gross storage capacity of the pickup is 2.62Mm³. The average rainfall in the command area is 680.65mm. The average monsoon rainfall

from June to November is 568.92mm. The nearest rain guage station is situated at Harihar in Davangere District.

The Command Area of this sub-project lies in zone-2 of Agroclimatic Region II ( North Dry zone of Karnataka). The Climate is suited for growing Cotton, Jawar, Maize, Navane, Sajje and Groundnut. The temperature ranges from $16^0$ C to $36^0$C. Fig 1 shows the location of the study area.
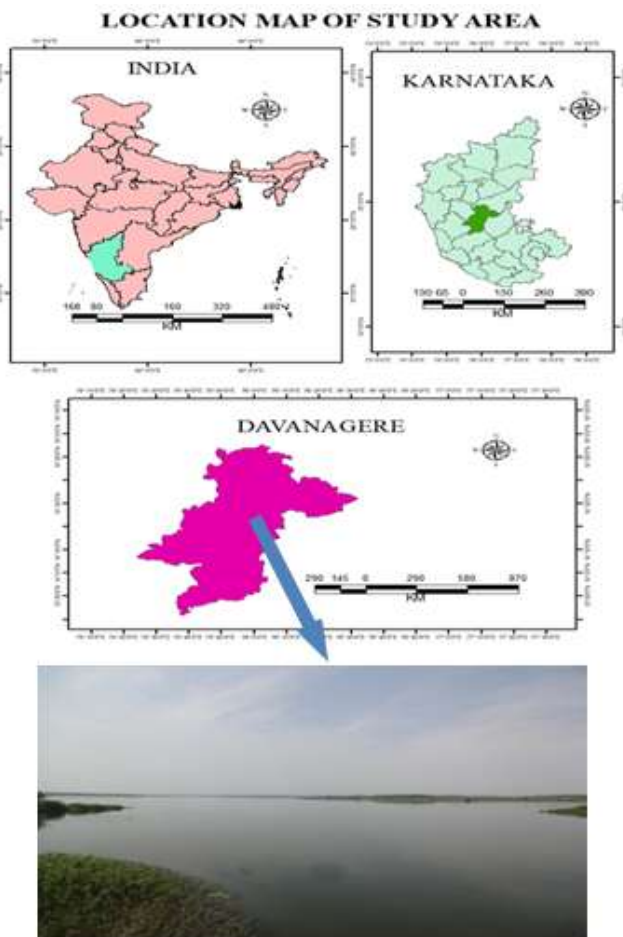


Fig.1 : Location of Devarabelakere Reservoir

## 1.2 Literature Review

**Adimasu Woldesenbet Worako (2015),** carried out study on physicochemical and biological water quality suitability for multiple purposes of Lake Hawassa and to find out the tropic state index of the lake from December 2011 to February 2012 at about period of three months. Lake Hawassa is situated in the southern regional state and it is one of the main Ethiopian Rift Valley Lakes. It receives water from only Tikurwuha River and it has a closed basin system. Every month water samples were collected from the lake and water quality parameters tests were conducted using standard methods. As the indices of SAR and EC/TDS values plays important role in the irrigation water quality, according to that lake water is in good condition. The value of the trophic state index was hypereutrophic for Lake Hawassa. On an average, the Lake Hawassa water is not fit for drinking, irrigation of some raw consuming crops and recreational but it is fit for aquatic life[2].

**Ansari and Hemke (2013),** the objective of study is to determine the suitability of ground water of different zones in Chandrapur city by analyzing the Water Quality Index (WQI). The aim of the index is to convert the Complex water quality data into the most simple and comprehensible data that can be easily understood by the policy makers and the general public as a whole. From the selected various zones of the city, the water samples in the rainy and winter seasons were collected for investigation in the present study and determined the various water quality parameters with reference to the drinking water standards and analysed for the suitability for the consumptions of the human beings. Obtained results shows that ground water quality of the various zones of the city is unsuitable for drinking purposes. Due to the increase in the microbial activity the deterioration of the water takes place from rainy to winter season. Hence by highlighting the major issue for availability of water for drinking purposes and proper measures are to be adopted due to the unhealthy human activities and growing industrialization[3].

**Javed Iqbal et.al., (2012),** carried out study to analyze the suitability of water from the Simly Lake, Pakistan. To determine the seasonal variations of physicochemical parameters ( pH, T, EC, TDS, DO, TH, TA, PS, $HCO_3$, $Cl^-$, RSBC, SAR and MAR) and essential metals such as Ca, K, Mg and Na were measured. By using various water quality parameters and indices, assessment of suitability of water for drinking and irrigation purpose was done. Maximum studied parameters concentrations were obtained to be within the national/ international standards. However, according to the international guidelines, the concentrations of bicarbonate ion and Residual Sodium Bicarbonate (RSC) were high in the water samples. According to the calculated irrigation water quality index, the Lake water falls under medium level and is suitable for the irrigation practice[4].

**Shiv Kumar Jaiswal et.al., (2017) ,** they carried out study on River Ganges, to determine the Water Quality Index (WQI) of the monsoon season water sample the main objective is to analyze the differences in River Ganges at different Ghats in Patna city, by using standard methods the physicochemical parameter for the water sample were analyzed the reading analyzed were then compared with the values of drinking water guidelines by World Health Organization (WHO) and Bureau of Indian Standard (BIS) sum of the obtain parameters were chosen to calculate WQI for the changes in the quality of water at each selected sampling site.WQI of River Ganges water at Patna City fall in the category of poor water quality and WQI value obtain ranged from 50.32 to 59.62. For analyzing quality of water, the obtain result shown that WQI may be a useful tool and predicting trend of changes in quality of water at various location in the River Ganges[5].

## 2. METHODOLOGY

### 2.1.  Location of Sampling:

Sampling has to be done by collecting the Devarabelakere reservoir water sample at different depths in Pre-Monsoon & Post- Monsoon season. The samples were collected in polythene bottles. These samples were analyzed for irrigation water quality parameters to check the suitability of this water for irrigation purpose.

The surface water samples were collected around the Devarabelakere reservoir for analysis of irrigation water quality. Simultaneously the water sample from the canal and stream as well as the sample from the irrigation return flow were collected. In Fig 2. Overview of the Devarabelekere reservoir with the command area and right and left bank canal is shown.



Fig. 2 : Image showing the study area

### 2.2.  Surface Water Quality

Analysis of seasonal changes in the quality of surface waters is an major aspect in evaluating the temporal variations in the water quality due to natural or anthropogenic inputs from the point or non-point sources. Analysis reveals that the parameters that are more important in contributing to quality of water in particular season may not be important in another season [Ouyang et.al.,2006].

In the present study, the physical and chemical characteristics of water samples has been done to analyze the irrigation water quality. To determine the surface water quality the water samples from reservoir, canal, return flow and stream has been collected for the analysis.

### 2.2.1  Reservoir Water Quality

The water sample from the respective reservoir i.e., Devarabelakere reservoir has been collected for the present study in the vicinity of right bank canal in Post Monsoon(i.e.,November 2018) and Pre Monsoon(i.e.,March 2019). Irrigation water quality has been determined for the same samples along with the water quality index for the irrigation purpose. The results of reservoir water quality which have been carried out in Pre and Post Monsoon have been mentioned in the table 1 below:

**Table -1:** Represent the results of Reservoir Water Quality

| Reservoir Water Quality | | | |
|---|---|---|---|
| Parameter | Post Monsoon | Pre Monsoon | Permissible Limits |
| pH | 7.29 | 8.45 | 6.5-8.5 |
| E C (ds/ m) | 0.566 | 0.387 | 0-3 |
| TDS (ppm) | 257.2 | 570 | 2000 |
| Total Hardness (mg/l) | 126 | 136 | 300 – 600 |
| Calcium (mg/l) | 24 | 15.2 | 200 |
| Magnissium (mg/l) | 15.84 | 23.52 | 100 |
| Chlorides (mg/l) | 44 | 82 | 1000 |
| Turbidity (NTU) | 5.32 | 5.4 | 5 to 10 |
| Sulphate (mg/l) | 32 | 58 | 400 |
| Sodium (me/l) | 5.45 | 1.03 | 200 |

### 2.2.2.  Canal Water Quality

The Canal and reservoir water samples were collected in both Pre and Post monsoon season and the irrigation water quality has been determined for the same.

The table 2 mentioned below will give the brief result of canal and reservoir water quality.

**Table 2**: Represent the result of Canal Water Quality

| Canal Water Quality | | | |
|---|---|---|---|
| Parameter | Post Monsoon | Pre Monsoon | Permissible Limits |
| pH | 7.43 | 8.34 | 6.5-8.5 |
| E C (ds/ m) | 0.552 | 0.387 | 0-3 |
| TDS (ppm) | 252.5 | 570 | 2000 |
| Total Hardness (mg/l) | 134 | 138 | 300 – 600 |
| Calcium (mg/l) | 23.2 | 18.4 | 200 |
| Magnissium (mg/l) | 18.24 | 22.08 | 100 |
| Chlorides (mg/l) | 42 | 78 | 1000 |
| Turbidity (NTU) | 5.91 | 5.48 | 5 to 10 |
| Sulphate (mg/l) | 30 | 58 | 400 |
| Sodium (me/l) | 5.28 | 1.07 | 200 |

### 2.2.3. Return Flow Water Quality

To determine the return flow water quality, the sample from excess water flow from the paddy field has been collected in both Pre and Post monsoon season and the irrigation water quality has been determined and observed that the acidity of return flow was exceeding its permissible limit in post monsoon.

The result of return flow water quality has been mentioned in the table 3;

**Table 3:** Represent the result of return flow Water Quality

| Return Flow Quality | | | |
|---|---|---|---|
| **Parameter** | **Post Monsoon** | **Pre Monsoon** | **Permissible Limits** |
| pH | 7.28 | 8.43 | 6.5-8.5 |
| EC (ds/ m) | 0.793 | 0.693 | 0-3 |
| TDS (ppm) | 359.8 | 1020 | 2000 |
| Total Hardness (mg/l) | 460 | 280 | 300 – 600 |
| Calcium (mg/l) | 54.4 | 52 | 200 |
| Magnissium (mg/l) | 77.76 | 36 | 100 |
| Chlorides (mg/l) | 70 | 190 | 1000 |
| Turbidity (NTU) | 8.6 | 10 | 5 to 10 |
| Sulphate (mg/l) | 152 | 102 | 400 |
| Sodium (me/l) | 5.36 | 2.36 | 200 |

### 2.2.4. Stream Water Quality

To determine the stream water quality the water sample from stream has been collected in both Pre and Post monsoon season and the irrigation water quality has been determined and observed that the acidity was exceeding its permissible limit in post monsoon.

The result of stream water quality has been mentioned in the below table 4:

**Table 4:** Represent the result of Stream Water Quality

| Stream Water Quality | | | |
|---|---|---|---|
| **Parameter** | **Post Monsoon** | **Pre Monsoon** | **Permissible Limits** |
| pH | 7.65 | 8.45 | 6.5-8.5 |
| EC (ds/ m) | 0.838 | 0.496 | 0-3 |
| TDS (ppm) | 384.8 | 730 | 2000 |
| Total Hardness (mg/l) | 228 | 182 | 300 – 600 |
| Calcium (mg/l) | 36 | 21.6 | 200 |
| Magnissium (mg/l) | 33.12 | 30.72 | 100 |
| Chlorides (mg/l) | 80 | 94 | 1000 |
| Turbidity (NTU) | 8.21 | 8.65 | 5 to 10 |
| Sulphate (mg/l) | 70 | 40 | 400 |
| Sodium (me/l) | 5.8 | 1.5 | 200 |

## 3. RESULTS AND DISCUSSION

According to IS 11624- 1986 the following chemical properties shall be considered for developing water quality criteria for irrigation[7].

a) Total salt concentration
b) Sodium Adsorption Ratio (SAR)
c) Residual Sodium Carbonate (RSC) or Bicarbonate ion concentration.

### 3.1. Sodium Adsorption Ratio (SAR )

It is noted as a best measure of sodium (alkali) hazard in the water used for irrigation purpose because it is directly related to the sodium adsorption on soil. And it is also a important criteria for analyzing the water suitability for irrigation purpose. Increased in the sodium concentration compared with the calcium and magnesium decreases the permeability of the soil and thus inhibits the water supply required by the crops. The SAR value measures the relative proportion of sodium ions present in the water sample to those of the calcium and magnesium ions present in the water samples [8]. And SAR value can be calculated by using the following formula:

$$SAR = \frac{Na^+}{\sqrt{(Ca^{+2} + Mg^{+2})/2}}$$

According to the Richards classification, the SAR value is divided into 4 categories. If the SAR value is less than 10 then the water sample is falls under the excellent category. And if

it is between 10-18 and 18-26, then the water sample is good and fair or medium for the irrigation usage respectively. And if it is greater than 26 than it is poor irrigation quality of water.

## 3.2.    Residual Sodium Carbonate (RSC)

The suitability of water for irrigation also influenced by the excess sum of the carbonate and bicarbonate in groundwater along with the sum of calcium and magnesium. A tendency for calcium and magnesium to precipitate is occurs due to the high concentration of bicarbonates in the water and hence the water in the soil becomes more concentrated. Increased concentration of the sodium bicarbonate and carbonate in water is considered to be detrimental to the soils physical property as it affects the dissolution of the organic matter in the soil, which results in the a black stain in the surface of the soil on drying. Due to this, this relative proportion of concentration of sodium in water is induced in the form of carbonates of sodium and this excess is denoted by RSC [8]. It can be calculated by using following formula:

$$RSC = (CO_3^- + HCO_3^-) - (Ca^{+2} + Mg^{+2})$$

**Table 5**: Represents irrigation water quality rating according to IS 11624-1986

| Sl. No | Class / Parameters | Low | Medium | High | Very high |
|---|---|---|---|---|---|
| 1 | Total salt concentration (micromhos/cm) | Below 1500 | 1500-3000 | 3000-6000 | Above 6000 |
| 2 | Sodium adsorption ratio ($\sqrt{\text{millimole}}$/liter) | Below 10 | 10-18 | 18-26 | Above 26 |
| 3 | Residual sodium carbonate or bicarbonate ion concentration (me/l) | Below 1.5 | 1.5-3.0 | 3.0-6.0 | Above 6.0 |

Calculated values for Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were listed in Table 6.

The obtained values of SAR for reservoir water, canal water, return flow water and stream water of Devarabelekere reservoir in both post monsoon and pre monsoon was found below 10 and hence it falls under low category. According to the SAR values obtained and compared with the standards given in codebook IS 11624 – 1986, the Devarabelekere reservoir water is suitable for irrigation purpose.

Similarly, the values of RSC for reservoir water, canal water, return flow water and stream water of Devarabelekere reservoir in both post monsoon and pre monsoon was found below 1.5. According to code IS 11624 – 1986, the Devarabelekere reservoir water is suitable for irrigation purposes.

**Table 6**: Represents irrigation water quality rating according to IS 11624-1986

| Sampling Location | SAR ($\sqrt{\text{millimole}}$/l) | | RSC (me/l) | |
|---|---|---|---|---|
| | Post Mon | Pre Mon | Post Mon | Pre Mon |
| **Reservoir** | 4.87 | 0.889 | 0.5 | 1.106 |
| **Canal** | 4.57 | 0.919 | 0.34 | 0.864 |
| **Return Flow** | 2.51 | 1.42 | 0.49 | 0.04 |
| **Stream** | 3.85 | 1.118 | 0.48 | 1.2 |

## 3.3. Water Quality Index

In the present study, for the calculation of the water quality index, weighted arithmetic index method is used. Ten major parameters were selected for the calculation of water quality index.

- **Quality Rating of Sub index Calculation ($q_n$)**

$$q_n = 100[(V_n - Vi_0)/(S_n - Vi_0)]$$

Where,

$q_n$ = quality rating for the $n^{th}$ water quality parameter.

Vn = obtained nth parameter value at a given sampling locations.

Sn = $n^{th}$ parameters standard permissible value.

$Vi_0$ = ideal value of $n^{th}$ parameter in pure water.

All the ideal values ($Vi_0$) are considered as zero (0) for all other parameters except the pH parameter, it is taken as 7.0.

- **Unit weight calculation (Wn)**

$$Wn = K/Sn$$

**Table 7:** Calculation of Water Quality Index

| K | 1.667 | | | | |
|---|---|---|---|---|---|
| Parameter | Test Values (Tn ) | Standard Values (Sn) | Wn= K/Sn | Qn = Tn/Sn *100 | Wn*Qn |
| pH | 7.29 | 8.5 | 0.196 | 19.333 | 3.791 |
| EC (μs/ cm) | 0.566 | 3 | 0.555 | 18.866 | 10.48 |
| TDS (ppm) | 257.2 | 500 | 0.003 | 51.44 | 0.171 |
| Total Hardness (mg/l) | 126 | 300 | 0.005 | 42 | 0.233 |
| Calcium (mg/l) | 24 | 75 | 0.022 | 32 | 0.711 |
| Magnissium (mg/l) | 15.84 | 30 | 0.055 | 52.8 | 2.933 |
| Chlorides (mg/l) | 44 | 250 | 0.006 | 17.6 | 0.117 |
| Turbidity (NTU) | 5.32 | 5-Jan | 0.333 | 106.4 | 35.473 |
| Sulphate (mg/l) | 32 | 200 | 0.008 | 16 | 0.133 |
| Sodium (me/l) | 5.45 | 200 | 0.008 | 2.725 | 0.0227 |
| | | | | | ∑Wn*Qn |
| | | | ∑Wn=1.195 | | =54.072 |
| Water Quality Index | 45.241 | | | | |

Where,

Wn = $n^{th}$ parameters unit weight.

Sn = $n^{th}$ parameters standard value.

K = Constant of proportionality.

- **WQI Calculation**

Water quality Index for the selected parameters can be calculated by using the expression,

$$WQI = \sum q_n Wn / \sum Wn$$

- **Water Quality Assessment**

According to the weighted arithmetic water quality index method, the WQI has been classified into 5 different classes. The table 8 gives the range of WQI , status and possible usage of the water samples [6].

**Table 8:** Water Quality Index (WQI ) range, its status and possible usage of the water sample.

| WQI Range | Water Quality Status | Possible Usage |
|---|---|---|
| 0-25 | Excellent water quality | Drinking, Irrigation and Industrial |
| 26-50 | Good water quality | Drinking, Irrigation and Industrial |
| 51-75 | Poor water quality | Irrigation and Industrial |
| 76-100 | Very poor water quality | Irrigation |
| Above 100 | Unsuitable for drinking and propagation of fish culture | Proper treatment required before use |

Similarly water quality index for various water samples for different parameters were calculated using the above method. Table 7 shows the calculation of WQI of reservoir water in the post monsoon season.

WQI was calculated for each of the sample in pre- monsoon and post- monsoon for analyzed parameters. According to this, post-monsoon reservoir water is suitable for irrigation purpose with water quality status good, where as pre-monsoon reservoir sample with water quality status poor, suitable for irrigation and industrial purpose. Canal water in the post monsoon and pre monsoon season with water quality status poor suitable for irrigation and industrial purpose. And the return flow water both in post and pre monsoon season is suitable only for irrigation with water quality status very poor. Stream water in post monsoon season with status poor suitable for irrigation and industrial purpose and pre monsoon season is only suitable for irrigation purpose with water quality status very poor. Tabulation of the results were shown in the Table 9.

## 3. CONCLUSIONS

Surface water, groundwater and return flow samples were collected from the different locations of Deverabelekere reservoir. Water samples from the all the sources were assed for different physico-chemical parameter. Water parameter were analyzed with irrigation water quality standards and water was found fit irrigation purpose except the return flow water. According to the temporal study of the reservoir water, pH, and turbidity values are high in Pre- monsoon season when compared to the Post- monsoon season. It is mainly due to the scarce supply of water to the reservoir and it makes the dam close. It leads to reservoir static.

**Table 9:** Representing Water Quality Index values

| | Post Monsoon | | | Pre Monsoon | | |
|---|---|---|---|---|---|---|
| | WQI | Water Quality Status | Possible usage | WQI | Water Quality Status | Possible usage |
| **Reservoir water** | 45.24 | Good | drinking, irrigation and industrial | 56.92 | Poor | Irrigation and Industrial |
| **Canal water** | 50.91 | Poor | Irrigation and Industrial | 56.01 | Poor | Irrigation and Industrial |
| **Return flow water** | 78.34 | Very Poor | Irrigation | 90.83 | Very Poor | Irrigation |
| **Stream water** | 72.93 | Poor | Irrigation and Industrial | 78.14 | Very Poor | Irrigation |

By the calculation of Water Quality Index , it was determined that reservoir water, canal water and stream water is suitable for irrigation purpose. Except return flow water both in post and pre monsoon season having water quality status very poor with greater WQI value. Because of the presence of fertilizers and pesticides  return flow water is rich in magnisium content and hence salinity. If the return flow water is repeatedly use in the downstream side, then it will be harm for both the soil and the crops. Hence proper treatment method is applied in that areas for reusing of the return flow water.

## REFERENCES

[1] Colonel Daniel Riviere, CM , PMP " The Thirsty Elephant – India's Water Security Challenges: A test for regional relations over the next decade", The Centre for Defence and Strategic Studies, September 2015.

[2] Adimasu Woldesenbet Worako, " Physicochemical and Biological water quality assessment of lake Hawassa for Multiple Designated Water Uses", Journal of Urban and Environmental Engineering, vol. 9 , n 2, p. 146-157.2015.

[3] Ansari K and Hemke N M., "Water Quality Index For Assessment Of Water Samples Of Different Zones In Chandrapur City", International Journal of Engineering

[4] Research and Applications (IJERA), ISSN: 2248-9622 ,Vol. 3, Issue 3, May-Jun 2013, pp.233-237, 2013.

[5] Javed Iqbal, Munir Hussain Shah, Syed Ahmed Tirmizi and Gulraiz Akhter, "Evaluation of Water Quality for drinking and Irrigation Purpose from Simly Lake, Pakistan", Journal – Chemical Society of Pakistan, Vol.34, No.6, 1565-1572,2012.

[6] Shiv Kumar Jaiswal, Vinay Kumar Gupta, Ajay Maurya, Reena Singh, "Changes in water quality index of different Ghats of Ganges River in Patna", IJETST- Vol.04, Issue 08, Pages 5549-5555,2017.

[7] Soraya Bouslah, Lakhdar Djemili, Larbi Houichi, "Water quality index assessment of Koudiat Medouar Reservoir, northeast Algeria using weighted arithmetic index method", Journal of Water and Land Development. No. 35 (X–XII), 221–228,2017.

[8] IS 11624 – 1986 Code Book.

[9] Mohammad Amin Bhat, Sheeraz Ahmad Wani, Vijay Kant Singh, Jyotirmaya Sahoo1, Dinesh Tomar, Ramprakash Sanswal, "An Overview of the Assessment of Groundwater Quality for Irrigation", Journal of Agricultural Science and Food Research, 9: 209, Volume 9  Issue1 ,.2018.