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# Evaluating industrial wastewater's impact on Walayar river:A GIS approach

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***ABSTRACT***

*Availability of fresh water is a major challenge in the current world and rapid expansion of industrialization and urbanization has worsened the situation. The present project work caused out to understand the level of water degradation of Walayar river, Palakkad, Kerala. Many locals are depending on this water source for their daily needs. Now there are several concerns regarding the safety of using Walayar river water for drinking and other uses due to an increase in industry and the accompanying discharge of untreated and semi-treated wastes into the river. These wastes, which were released into the water system from various industries, changed the physiochemical and biological characteristics of riverine ecology. During the present investigation the pH, total alkalinity and acidity, hardness, iron, chloride, conductivity, turbidity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand and coliform were observed during summer and winter seasons. Water samples were collected from 10 locations in Walayar river and water quality parameters were determined. By using these water quality parameters water quality index was also determined. Additionally, utilizing GIS mapping, the results are then geographically displayed.*

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## I. INTRODUCTION

Water pollution is notable issue for sustainable development and poses a serious threat to human health among other types of pollution. Due to anthropogenic activity, many rivers in emerging nations are severely contaminated. In recent years, particularly in light of the prospect of fresh water has gained significant importance. The most significant sources of fresh water are rivers. Unfortunately, indiscriminate sewage disposal, industrial waste, and human activity are all contributing to the pollution of the waterway. In many nations, the quality of the surface water is a particularly sensitive and important problem. Additionally, as the significance of raw water quality for aquatic life and drinking water quality for public health has become more widely recognised. Surface waters are degraded and rendered less useful for drinking, industry, agriculture, recreation, and other uses due to anthropogenic factors as well as natural processes. So, a water quality monitoring program is necessary for the protection of fresh water resources. The use of a WQI was initially proposed by Horton (1965) and Brown et al. (1970). Then, many different methods for the calculation of WQI's have been developed by several authors. Based on the application of common parameters for water characterization, the WQI has been taken into consideration as one criterion for surface water classifications. It gives a thorough picture of the water quality for the majority of residential uses. Large amounts of data on the characterization of water are reduced using a mathematical tool called the Water Quality Index (WQI) into a single number that represents the water quality level. The results of our field study which assessed seasonal changes in the physiochemical parameters and nutrient load of the river Walayar, Palakad district of Kerala.

## II. MATERIALS AND METHODS

**Site selection**

Walayar river was visited as the part of the study. The water samples were collected from 10 different station points based on the industrial effluent outlet and on the survey conducted to the locality. Out of these 10 stations, the first 2 are located before the industrial area and the following 5 are close to the industrial area, and they are spaced roughly 3 km apart. The final 3 stations are located after the industrial area which are 3-5km apart. The industrial areas include MANJALYCO INDUSTRIES, BOSS RUBBER INDUSTRIES, Innotek Industries Pvt.Ltd, Precot Meridian C Unit, Malabar Cement LTD, LEMAX INDUSTRIES, Mother Agro Industries, Emirates Cements India Pvt Ltd etc. These industries manufacture rubber products, cement, textile products, battery, and glass refractories and so on.

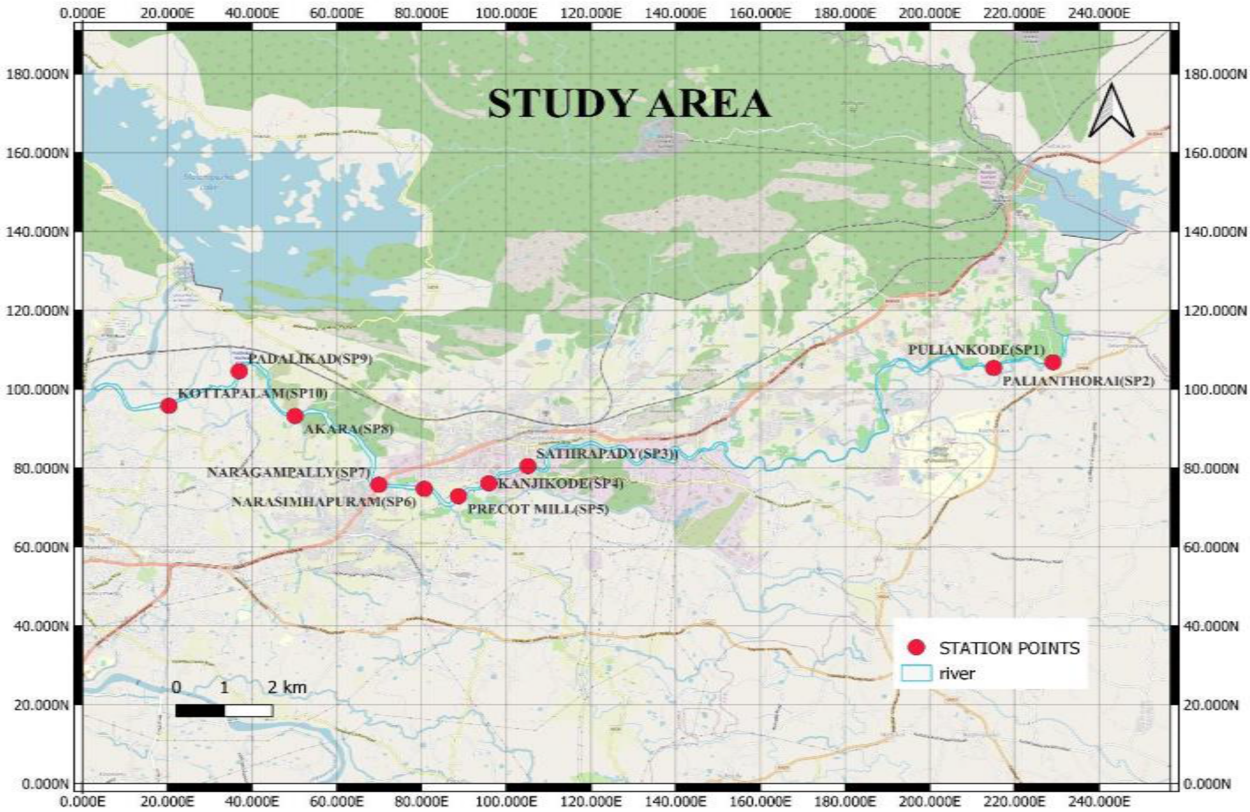



Fig 1: station points

**Sampling**

The method of sampling employed in a water survey must ensure that representative samples are acquired. Because the information obtained from the analysis of the sample will eventually be used to develop treatment facilities. There are no standard sampling procedures. Each case requires a different sampling strategy, which must be properly adjusted.

**Sample collection**

The water samples for the experimental study were collected in 1L polythene canes from 10 stations. Gloves were worn prior to the sample collection. The canes were sterilized with distilled water and were dried before collecting the sample. To collect the samples, the canes were wade into the middle of the river and positioned such that they faced the current. This is done so that any possible contamination will flow away from where the sample is being collected.

**Sample preservation**

The determination of water quality does not require any specific sample preservation. In the interval between sample collection and sample analysis, the sample's integrity is not maintained. The samples were analyzed for a variety of physio-chemical characteristics using established techniques. Titration methods were used to determine Total Alkalinity, COD, BOD, Dissolved Oxygen, and Hardness.

**GIS mapping**

GIS mapping was done using QGIS software. Mapping of each station point was done using the data obtained from experimental results. Google Earth and Google Maps were utilized for obtaining latitudes and longitudes of location for mapping.

**Determination of parameters**

Various parameters like pH, alkalinity, electrical conductivity, dissolved oxygen, turbidity, Biological Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Iron, total solids, Sulphates, Chlorides, Coliforms in water etc. were determined for the water collected in summer season and winter season from the ten station points.

## III. RESULTS OF VARIOUS PARAMETERS

| Parameters | Permissible concentration (BIS standards) |
|---|---|
| PH | 6.5-8.5 |
| CONDUCTIVITY (µs/cm) | <750 |
| TURBIDITY (NTU) | 0-10 |
| ALKALINITY (mg/L) | 20-200 |
| DO (mg/L) | >6 |
| BOD (mg/L) | <30 |
| COD (mg/L) | <250 |
| HARDNESS (mg/L) | 0-200 |
| IRON (ppm) | 0.3 |
| CHLORIDE (mg/L) | 0-250 |
| SULPHATE | <200 |
| TOTAL DISSOLVED SOLIDS | <500 |
| TOTAL COLIFORM | <1 |

**Table 1 Permissible limits**

| PARAMETERS | SP 1 | SP 2 | SP 3 | SP 4 | SP 5 | SP 6 | SP 7 | SP 8 | SP 9 | SP10 |
|---|---|---|---|---|---|---|---|---|---|---|
| PH | 7.76 | 7.59 | 7.28 | 8.34 | 8.67 | 8.7 | 8.27 | 8.07 | 8.34 | 7.61 |
| CONDUCTIVITY (µs/cm) | 385 | 330 | 495 | 495 | 440 | 825 | 770 | 660 | 330 | 110 |
| TURBIDITY (NTU) | 3.8 | 3.4 | 11.1 | 5.9 | 8.5 | 8.9 | 6.7 | 9.4 | 12 | 9.7 |
| ALKALINITY (mg/L) | 200 | 186 | 330 | 296 | 194 | 184 | 210 | 190 | 152 | 92 |
| DO (mg/L) | 6.9 | 8.2 | 1.5 | 6.8 | 8.3 | 6.8 | 6.4 | 6.2 | 12 | 9.7 |
| BOD (mg/L) | 15.2 | 15.2 | 32.8 | 14.5 | 11.2 | 21.2 | 12.3 | 7.2 | 8.4 | 8 |
| COD (mg/L) | 64 | 96 | 320 | 128 | 32 | 128 | 64 | 32 | 32 | 32 |
| HARDNESS (mg/L) | 280 | 244 | 340 | 312 | 216 | 220 | 284 | 268 | 188 | 148 |
| IRON (ppm) | 0.1 | 0.1 | 0.8 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| CHLORIDE (mg/L) | 70 | 53 | 182 | 139 | 124 | 118 | 139 | 162 | 85 | 18 |
| SULPHATE | 49.39 | 139.94 | 246.96 | 218.81 | 82.32 | 164.64 | 98.78 | 131.71 | 107.02 | 79.48 |
| TOTAL DISSOLVED SOLIDS | 500 | 410 | 1200 | 510 | 530 | 600 | 650 | 550 | 600 | 580 |
| TOTAL COLIFORM | <1 | 4 | 2400 | 110 | 4 | <1 | <1 | 3 | 4 | 3 |

**Table 2 Winter season**

| PARAMETERS | SP 1 | SP 2 | SP 3 | SP 4 | SP 5 | SP 6 | SP 7 | SP 8 | SP 9 | SP10 |
|---|---|---|---|---|---|---|---|---|---|---|
| PH | 7.64 | 7.63 | 7.71 | 7.75 | 7.8 | 7.68 | 8.27 | 8.24 | 7.93 | 7.71 |
| CONDUCTIVITY (µs/cm) | 330 | 275 | 550 | 495 | 440 | 495 | 385 | 550 | 495 | 275 |
| TURBIDITY (NTU) | 2.5 | 1.5 | 3.4 | 5 | 2.9 | 2.6 | 5 | 0.9 | 0.8 | 1.2 |
| ALKALINITY (mg/L) | 198 | 170 | 316 | 298 | 210 | 230 | 190 | 173 | 90 | 110 |
| DO (mg/L) | 8.5 | 7.3 | 2.4 | 5.3 | 7.8 | 6.2 | 4.1 | 7.9 | 8.9 | 7.6 |
| BOD (mg/L) | 2.4 | 2.5 | 13.6 | 2.8 | 2.6 | 3.2 | 2.8 | 1.2 | 0.4 | 0.6 |
| COD (mg/L) | 64 | 96 | 260 | 128 | 64 | 128 | 160 | 96 | 64 | 32 |
| HARDNESS (mg/L) | 192 | 192 | 336 | 312 | 190 | 210 | 252 | 220 | 244 | 172 |
| IRON (ppm) | 0.1 | 0.1 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| CHLORIDE (mg/L) | 69 | 72 | 77 | 111 | 108 | 135 | 145 | 142 | 134 | 87 |
| SULPHATE | 96.23 | 110.57 | 258.9 | 232.45 | 182.52 | 159.88 | 77.69 | 122.46 | 108.7 | 65.91 |
| TOTAL DISSOLVED SOLIDS | 350 | 800 | 680 | 520 | 580 | 600 | 510 | 630 | 540 | 500 |
| TOTAL COLIFORM | <1 | <1 | 15 | 4 | 4 | 3 | 3 | 4 | 3 | 3 |

**Table 3 Summer season**

## IV. WATER QUALITY INDEX

The water quality index provides a numerical representation of the overall quality of water for any intended purpose. It is characterized as a grade that captures the combined influence of many water quality criteria that were taken into account while calculating the Water Quality Index (WQI). The indices are among the most efficient means of informing the public, policymakers, and others involved in water quality management about trends in water quality. Depending on how the water will be used, different criteria have varying degrees of importance when calculating the water quality index. Most of the time, it is done with consideration for whether it is fit for human consumption. There are several methods for calculating WQI. They are, weighted arithmetic water quality index (WAQI),Canadian council of ministers(CCME WQI) and Oregon water quality index (OWQI)

**Weighted arithmetic method**

| WQI | WATER QUALITY STATUS |
|---|---|
| 0-25 | EXCELLENT |
| 26-50 | GOOD |
| 51-75 | BAD |
| 76-100 | VERY BAD |
| 100 & ABOVE | UNFIT |

**Table 4 Water quality status**

Let there be n water quality parameters and quality rating (Qn) corresponding to n th parameter is a number reflecting relative value of this parameter in the polluted water with respect to its standard permissible value . Qn values are given by the relationship.

Qn = [(Vn - Vo) / (Sn-Vo)] *100

Sn = Standard value, Vn = observed value, Vo = ideal value.

In most cases Vo = 0 except in certain parameters like pH, dissolved oxygen etc.,

Calculation of quality rating for pH & DO (Vo ≠0)

Q pH = 100 (VPH – 7.0) / (8.5 – 1.0)

Calculation of unit weight: The Unit weight (Wn) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

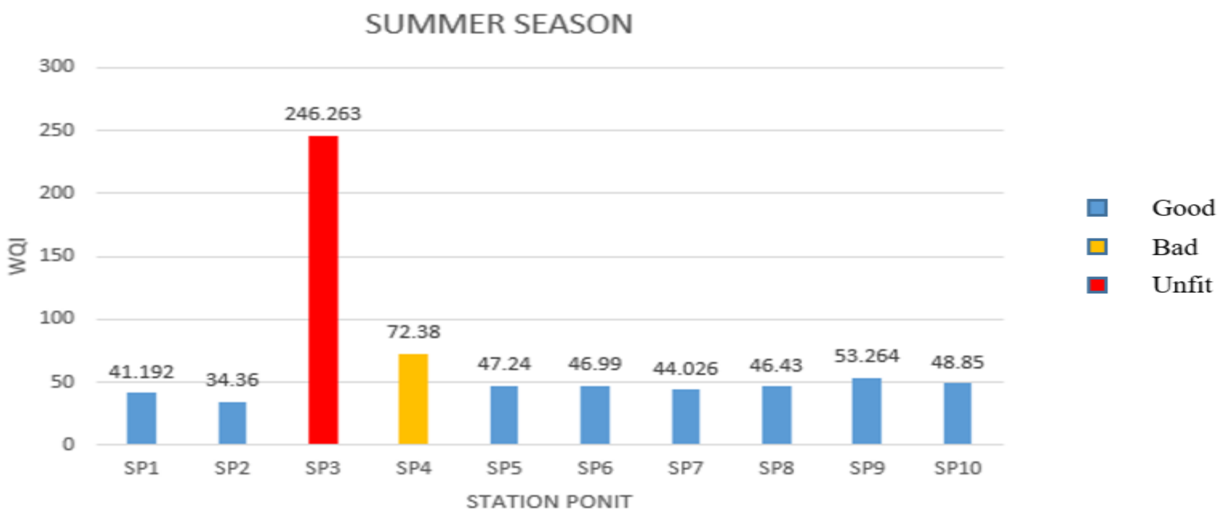
Wn = k/sn.

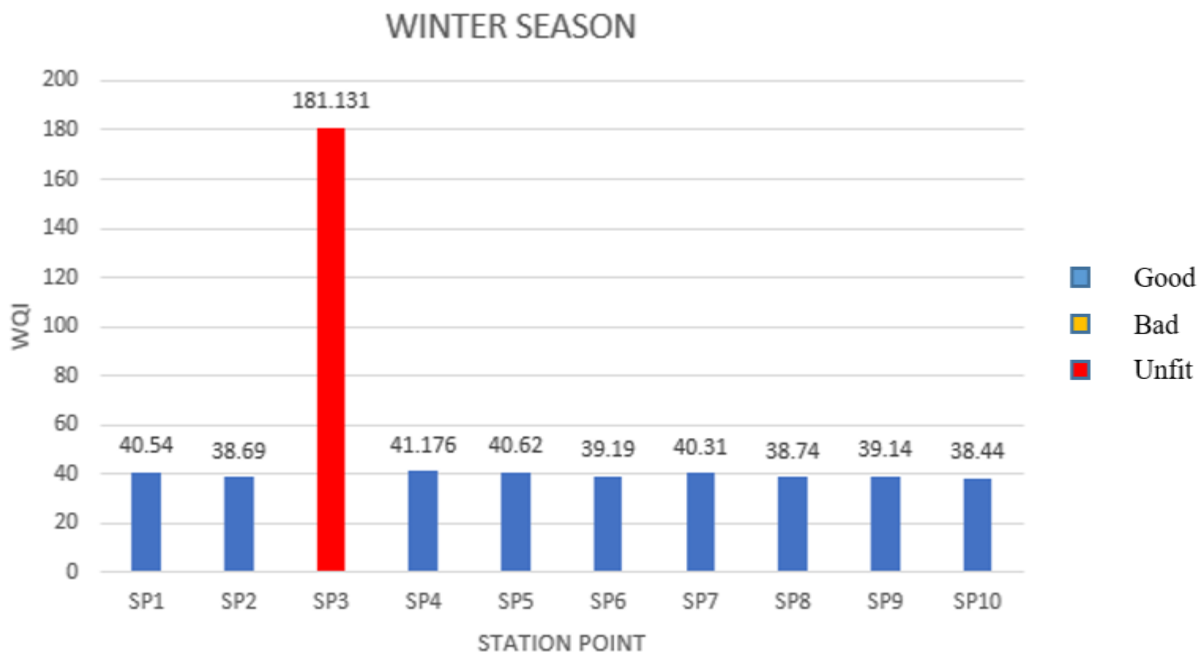
Where wn = unit weight for nth parameter.

sn = standard permissible value for nth parameter

k= proportionality constant.

WQI = Σ Qn Wn / Σ Wn



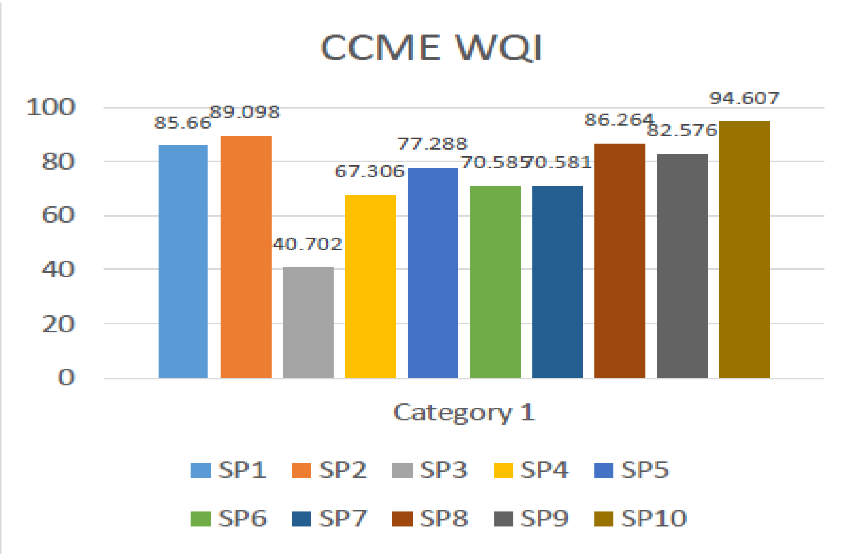




**Canadian council of ministers of environment(CCME) method**

The Canadian Council of Ministers of the Environment also developed a WQI to organize the disclosure of complex and extensive water quality data (CCME 2001). The result of the WQI calculation is a single number that lacks units and ranges from 0 to 100.
The constant, 1.732, is a scaling factor to ensure that the index varies between 0 and 100.
F1 = (No: of failed parameters / Total no: of parameters) *100
F2 = (No: of failed tests / Total no.of test ) *100
Excursion = (Failed test value / Objective) -1
When the test value must not fall below the objective,
Excursion = (Objective / Failed test value) -1
The standardized entirety of excursions, nse, is the aggregate sum by which individual tests are out of consistence.
nse=Σ excursions / no. of tests
F3 is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range from 0 to 100.
F3 = (nse / 0.01* nse+ 0.01)

| RANK | VALUE |
|---|---|
| EXCELLENT | 95-100 |
| GOOD | 80-94 |
| FAIR | 65-79 |
| MARGINAL | 45-64 |
| POOR | 0-44 |

**Table 5 WQI categorization on the basis of CCME**

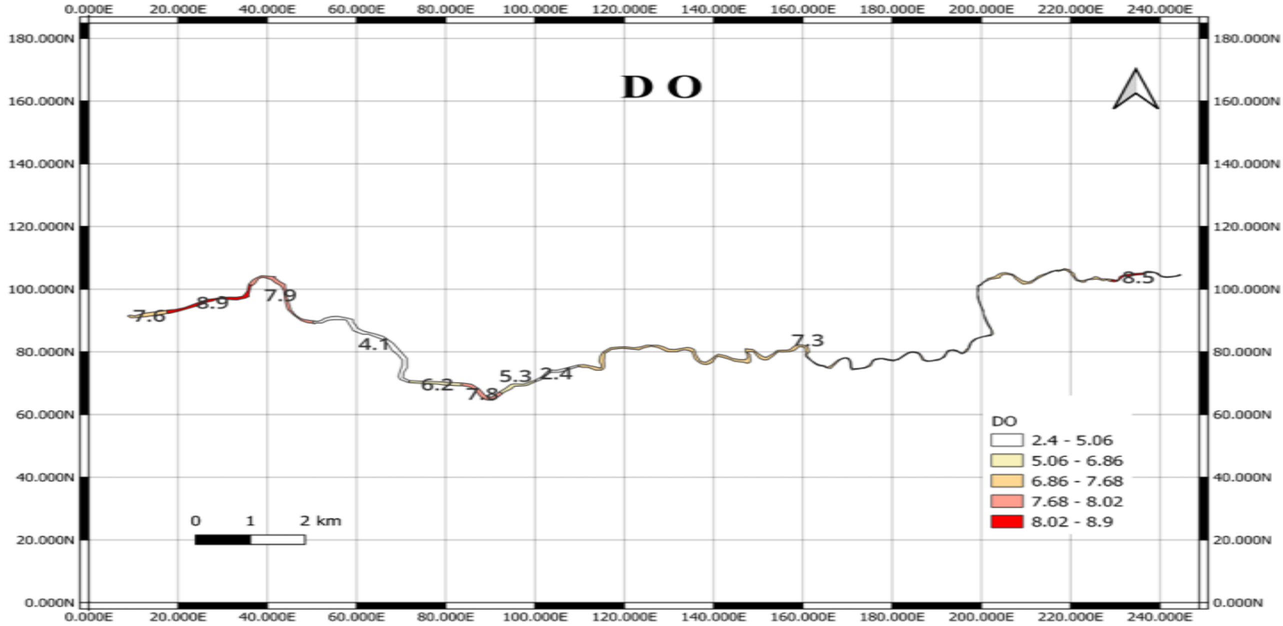


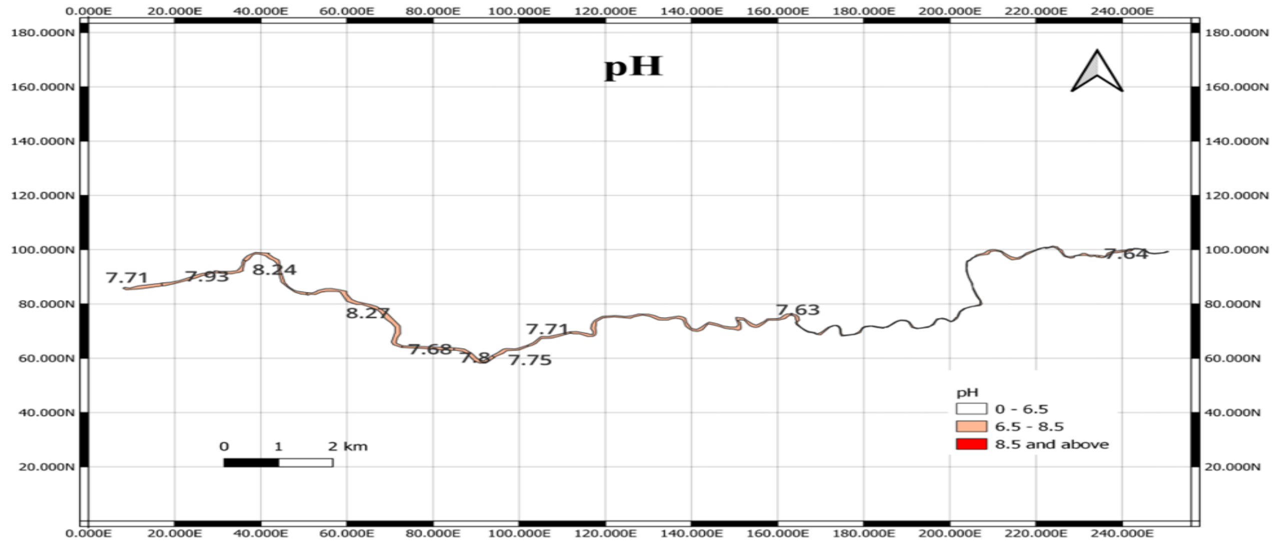

The water quality in station point 3 is very poor and that of station point 4 is fair.

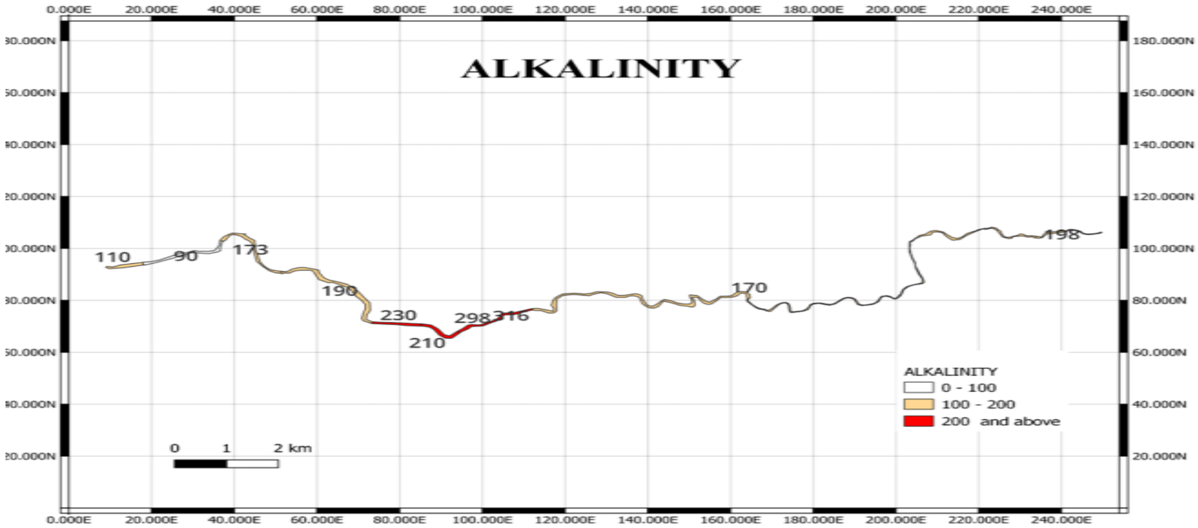
## V. GIS MAPPING

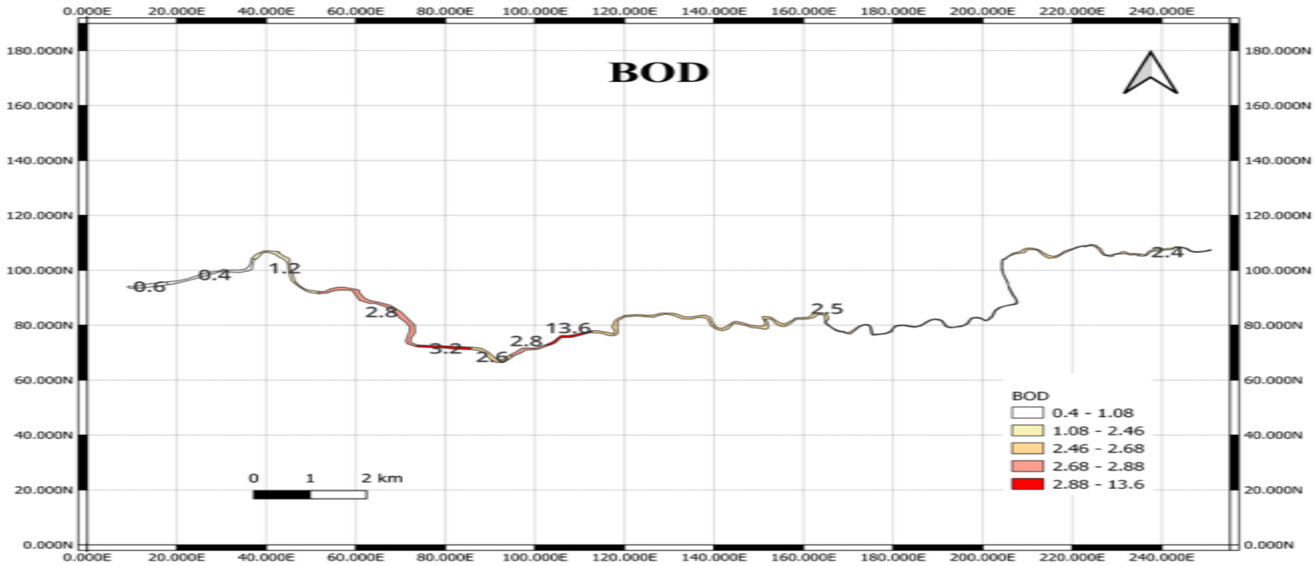
A Geographic Information System (GIS) is a computer system that analyzes and displays geographically referenced information. It uses the data attached to a unique location. Here the water samples were analyzed by using standard methods and the following are the GIS maps of our study area with reference to our test results. Interpolation in GIS is done by Inverse Distance Weighting(IDW) Technique. It is a type of deterministic method for multivariate interpolation with a known scattered set of point.

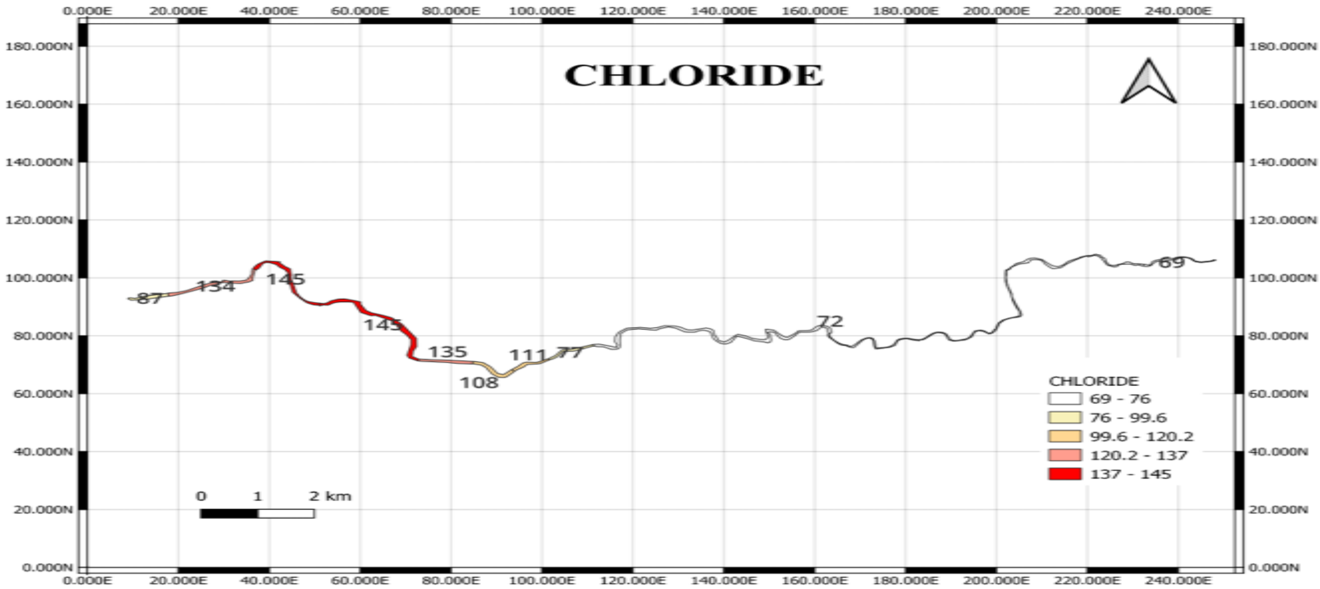
**Mapping of winter season**

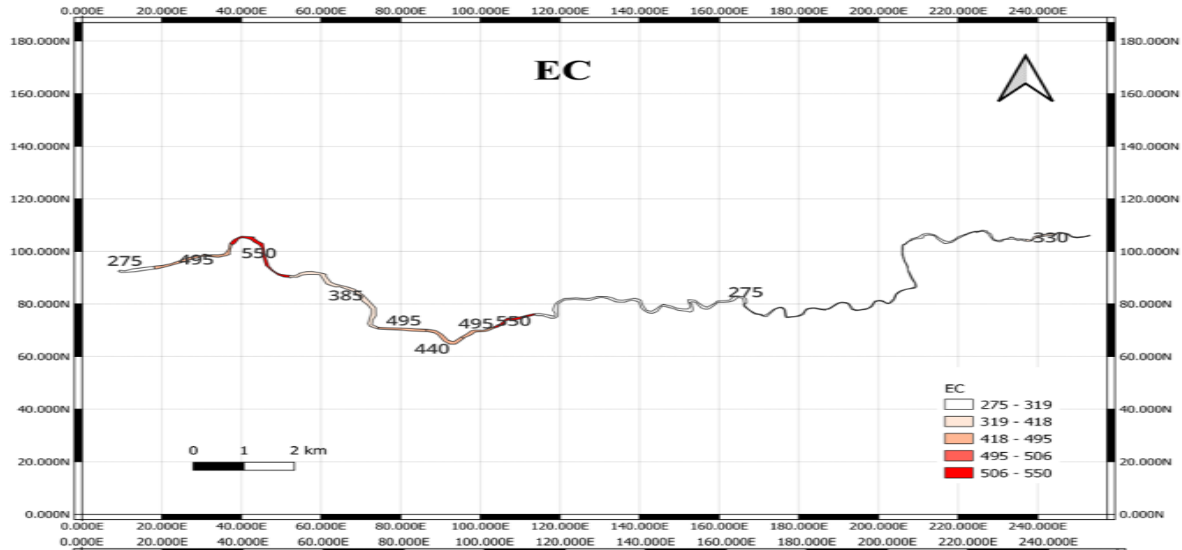




ALKALINITY
110
90
173
190
230
210
298
316
170
198
ALKALINITY
0 - 100
100 - 200
200 and above
0 1 2 km

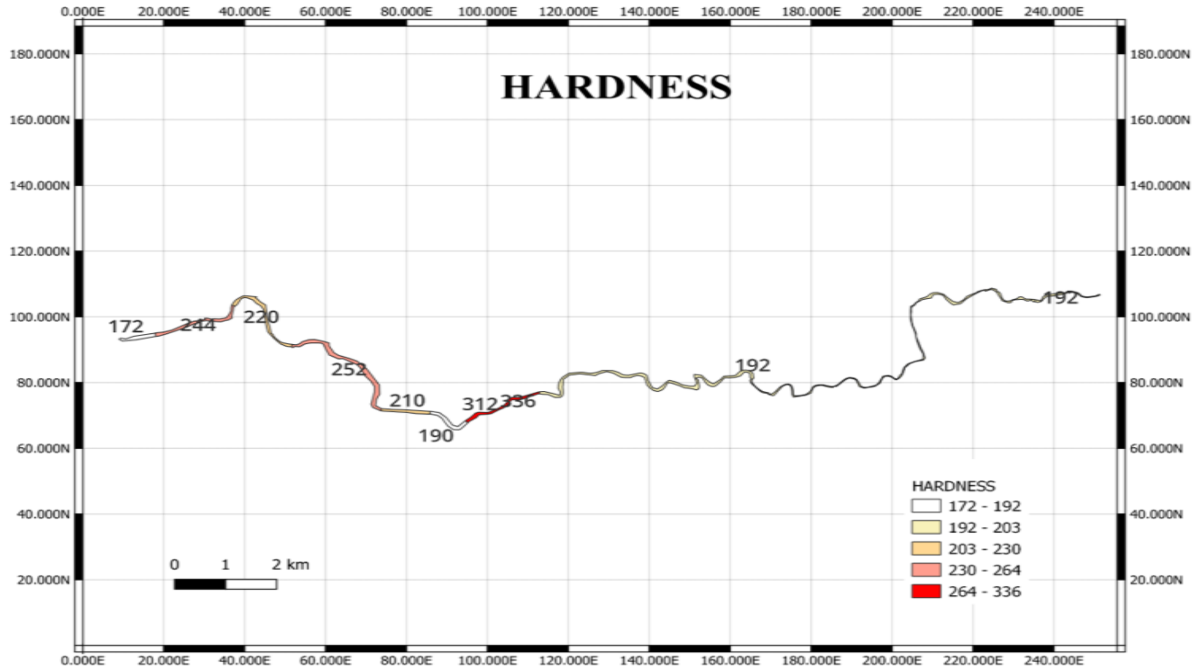

BOD
0.6
0.4
1.2
2.8
3.2
2.6
2.8
13.6
2.5
2.4
BOD
0.4 - 1.08
1.08 - 2.46
2.46 - 2.68
2.68 - 2.88
2.88 - 13.6
0 1 2 km


CHLORIDE
87
134
145
145
135
108
111
77
72
69
CHLORIDE
69 - 76
76 - 99.6
99.6 - 120.2
120.2 - 137
137 - 145
0 1 2 km

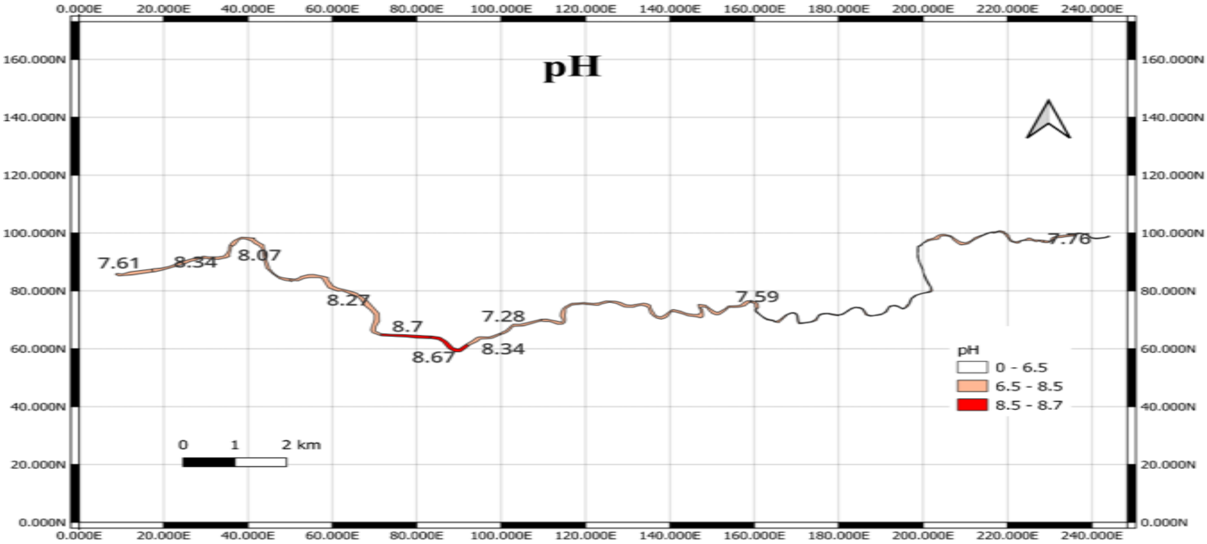

EC
275
495
550
385
495
440
495
550
275
330
EC
275 - 319
319 - 418
418 - 495
495 - 506
506 - 550
0 1 2 km

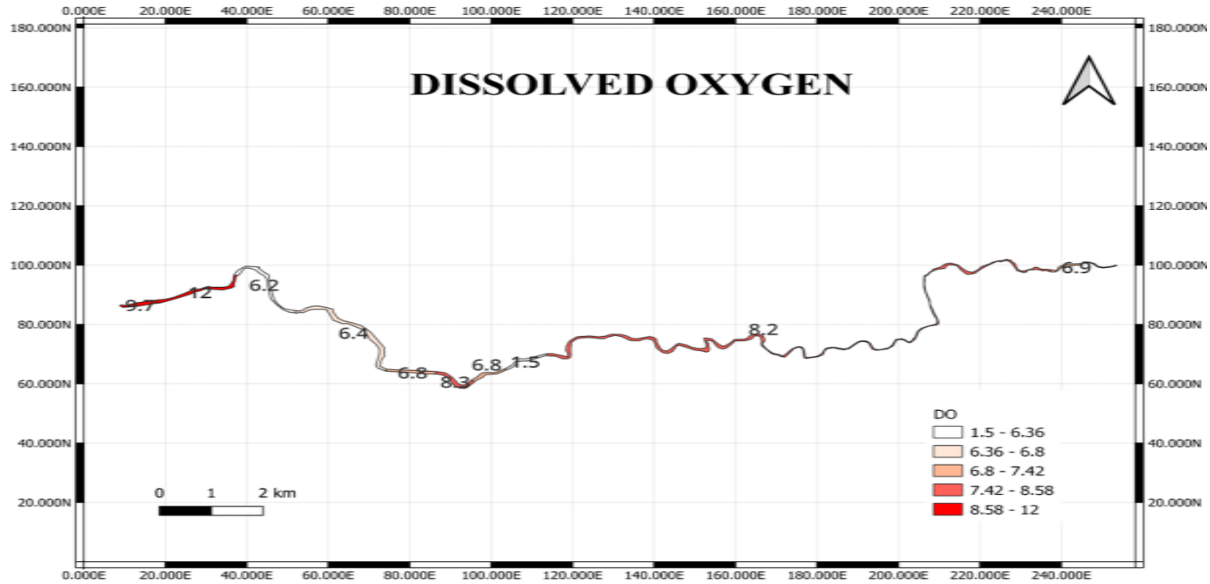
A

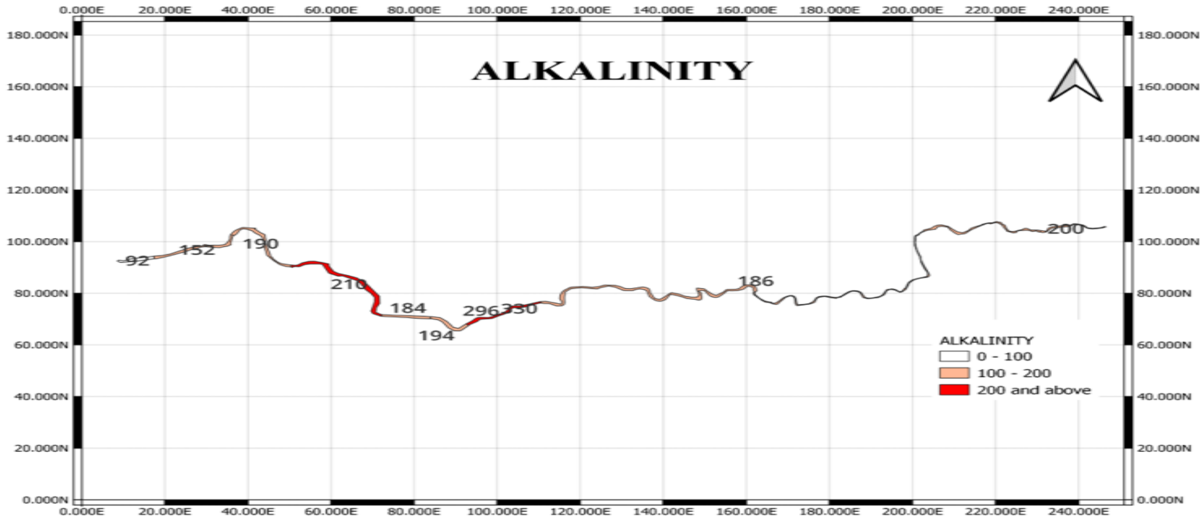

IRON
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.8
0.1
0.1
IRON
0 - 0.3
0.3 - 0.8
0 1 2 km


HARDNESS
172
244
220
252
210
190
312
336
192
192
HARDNESS
172 - 192
192 - 203
203 - 230
230 - 264
264 - 336
0 1 2 km

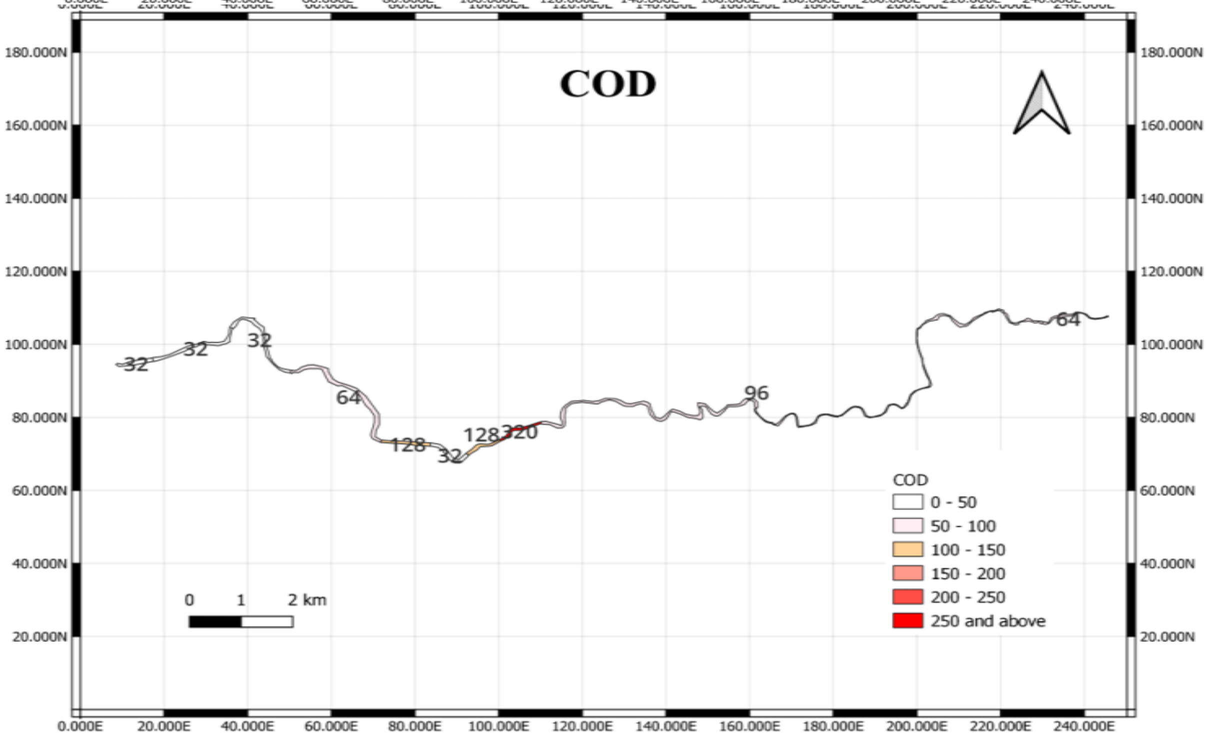
**Mapping of summer season**

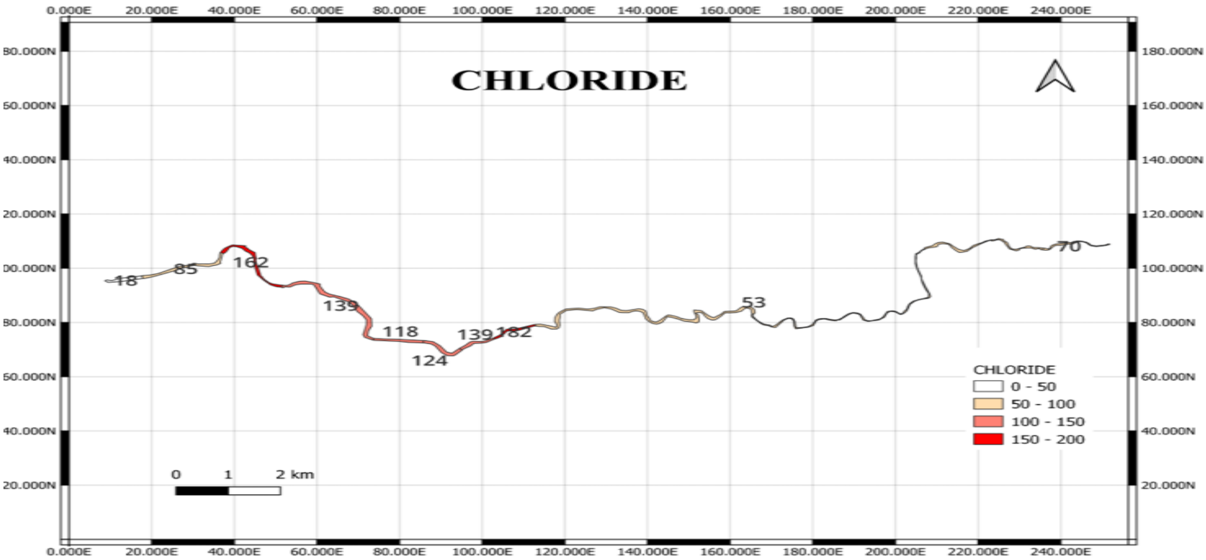


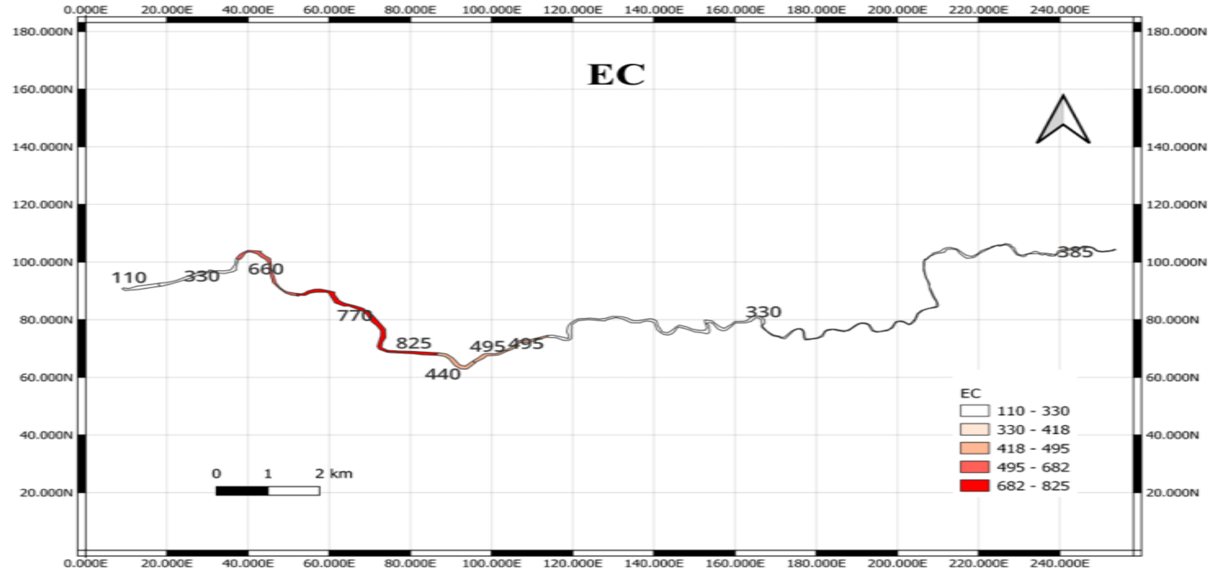





ALKALINITY
92
152
190
210
184
194
296
330
186
200
ALKALINITY
0 - 100
100 - 200
200 and above
0.000E 20.000E 40.000E 60.000E 80.000E 100.000E 120.000E 140.000E 160.000E 180.000E 200.000E 220.000E 240.000E
0.000N 20.000N 40.000N 60.000N 80.000N 100.000N 120.000N 140.000N 160.000N 180.000N


BOD
8
8.4
7.2
12.3
21.6
11.2
14.5
32.8
15.2
15.2
BOD
0 - 10
10 - 20
20 - 30
30 and above
0 1 2 km
0.000E 20.000E 40.000E 60.000E 80.000E 100.000E 120.000E 140.000E 160.000E 180.000E 200.000E 220.000E 240.000E
20.000N 40.000N 60.000N 80.000N 100.000N 120.000N 140.000N 160.000N 180.000N


COD
32
32
32
64
128
32
128
320
96
64
COD
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 and above
0 1 2 km
0.000E 20.000E 40.000E 60.000E 80.000E 100.000E 120.000E 140.000E 160.000E 180.000E 200.000E 220.000E 240.000E
20.000N 40.000N 60.000N 80.000N 100.000N 120.000N 140.000N 160.000N 180.000N


CHLORIDE
18
85
162
139
118
124
139
182
53
70
CHLORIDE
0 - 50
50 - 100
100 - 150
150 - 200
0 1 2 km


EC
110
330
660
770
825
440
495
495
330
385
EC
110 - 330
330 - 418
418 - 495
495 - 682
682 - 825
0 1 2 km


HARDNESS
148
188
268
284
220
216
312
340
244
280
HARDNESS
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
0 1 2 km


## VI. CONCLUSION

The study showcases the impact of various industries on Walayar river and their spatial representation through GIS. Water samples were collected and tested properly to know the physical, chemical and biological parameters of river water from various locations. Parameters such as pH, Turbidity, Conductivity, Hardness, alkalinity, Chlorides, Sulphates, Iron, TDS, DO, BOD, COD, Total Coliforms were determined for summer and winter seasons. The water quality index of the river was determined and compared by using weighted arithmetic method and CCME method. From the results it can be concluded that station point 3 was highly polluted in both seasons. This is due to the severe pollution caused by the steel industries and waste dumping etc. Then, the obtained results were represented through GIS mapping using Q GIS software. The GIS maps were used to identify the pollution hotspots in the studied area.

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