

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, Palakkad 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.

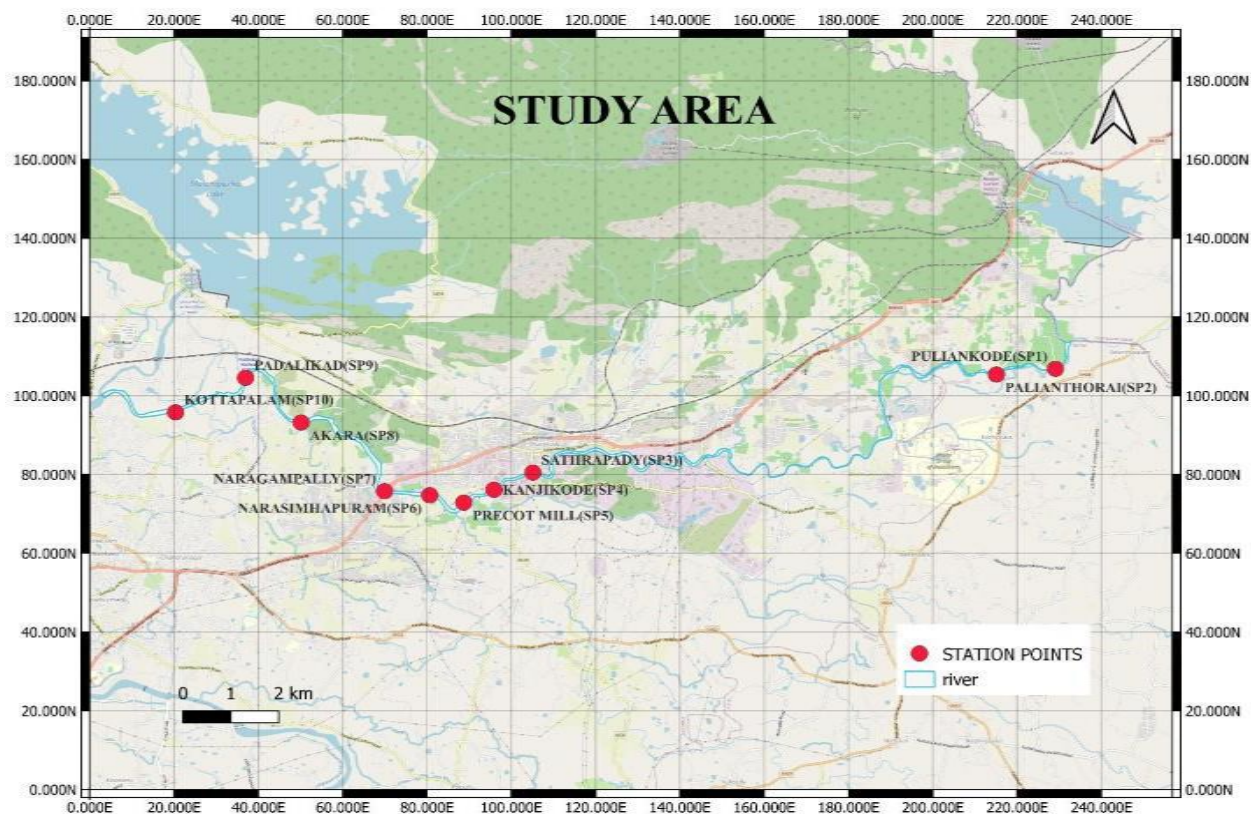


Fig 1: station points

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 waded 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 ($\mu\text{s}/\text{cm}$)	<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 ($\mu\text{s}/\text{cm}$)	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 ($\mu\text{s}/\text{cm}$)	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.

$$Q_n = [(V_n - V_o) / (S_n - V_o)] * 100$$

S_n = Standard value, V_n = observed value, V_o = ideal value.

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

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

$$Q_{pH} = 100 (V_{pH} - 7.0) / (8.5 - 1.0)$$

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

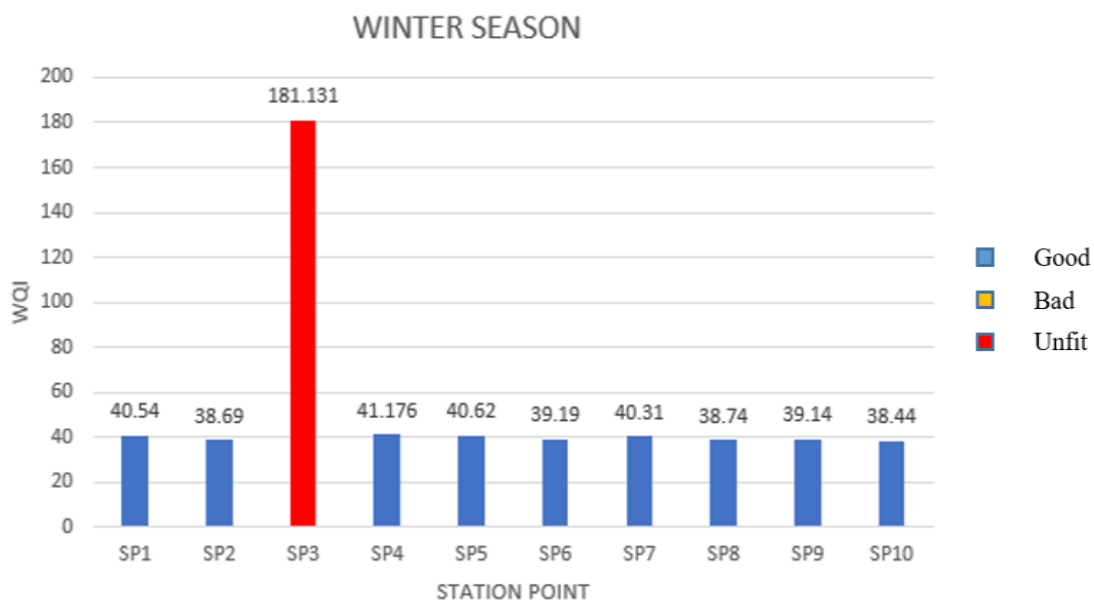
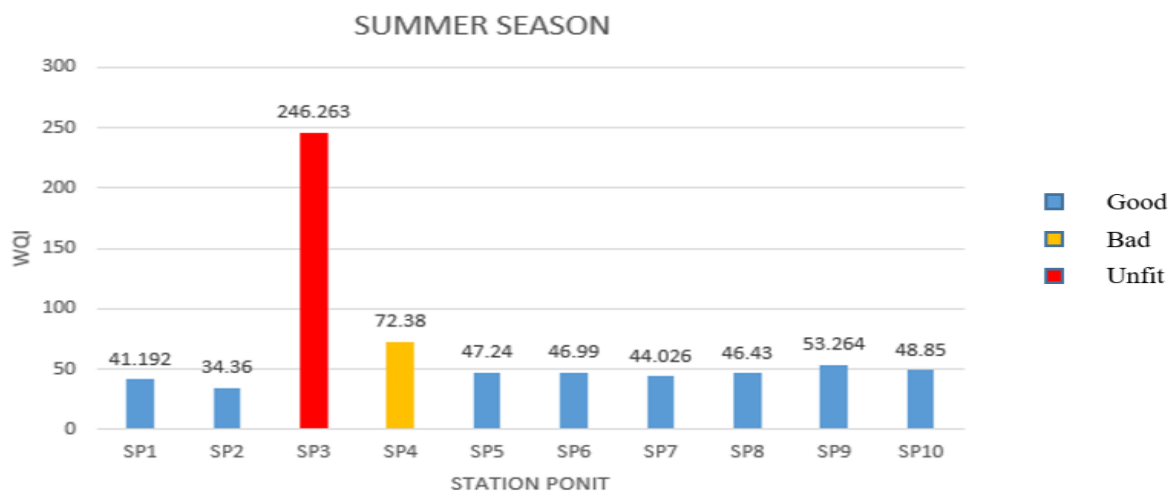
$$W_n = k/s_n.$$

Where w_n = unit weight for nth parameter.

s_n = standard permissible value for nth parameter

k= proportionality constant.

$$WQI = \sum Q_n W_n / \sum W_n$$



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.

$$F1 = (\text{No: of failed parameters} / \text{Total no: of parameters}) * 100$$

$$F2 = (\text{No: of failed tests} / \text{Total no.of test}) * 100$$

$$\text{Excursion} = (\text{Failed test value} / \text{Objective}) - 1$$

When the test value must not fall below the objective,

$$\text{Excursion} = (\text{Objective} / \text{Failed test value}) - 1$$

The standardized entirety of excursions, nse, is the aggregate sum by which individual tests are out of consistence.

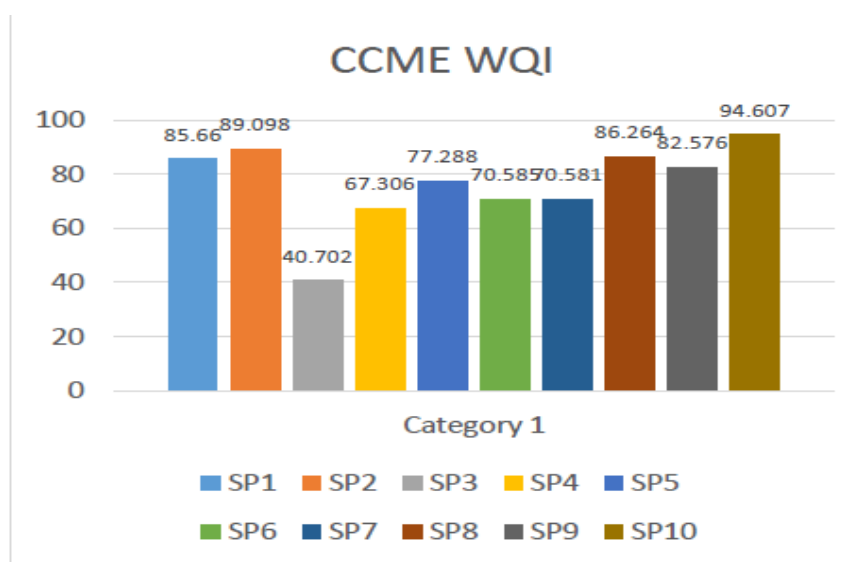
$$nse = \sum \text{excursions} / \text{no. of tests}$$

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

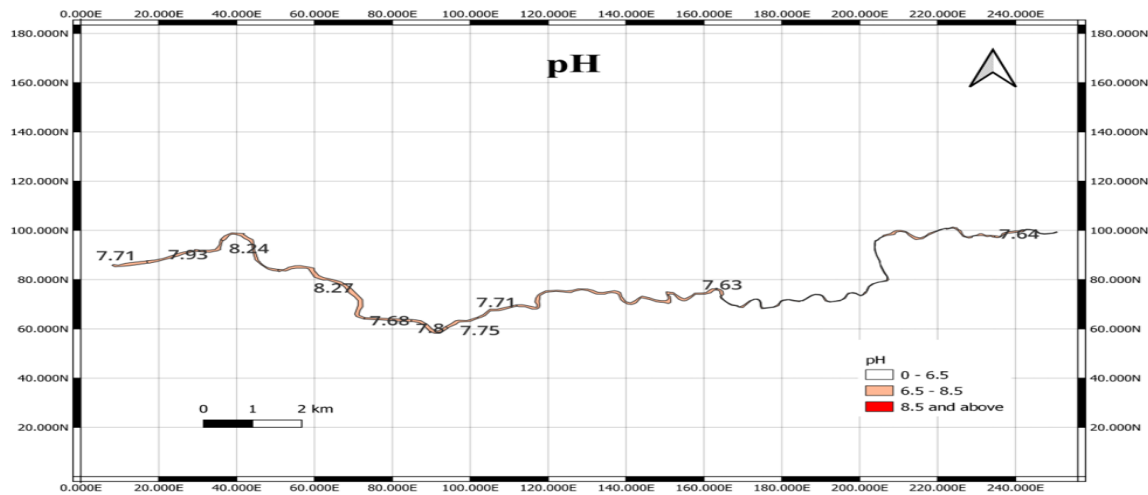
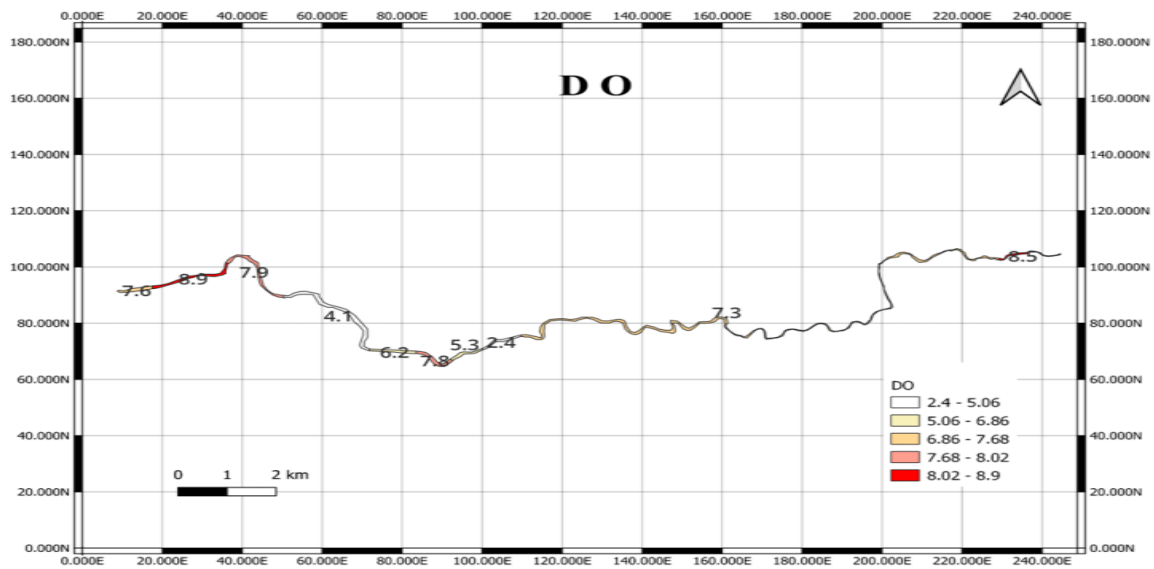


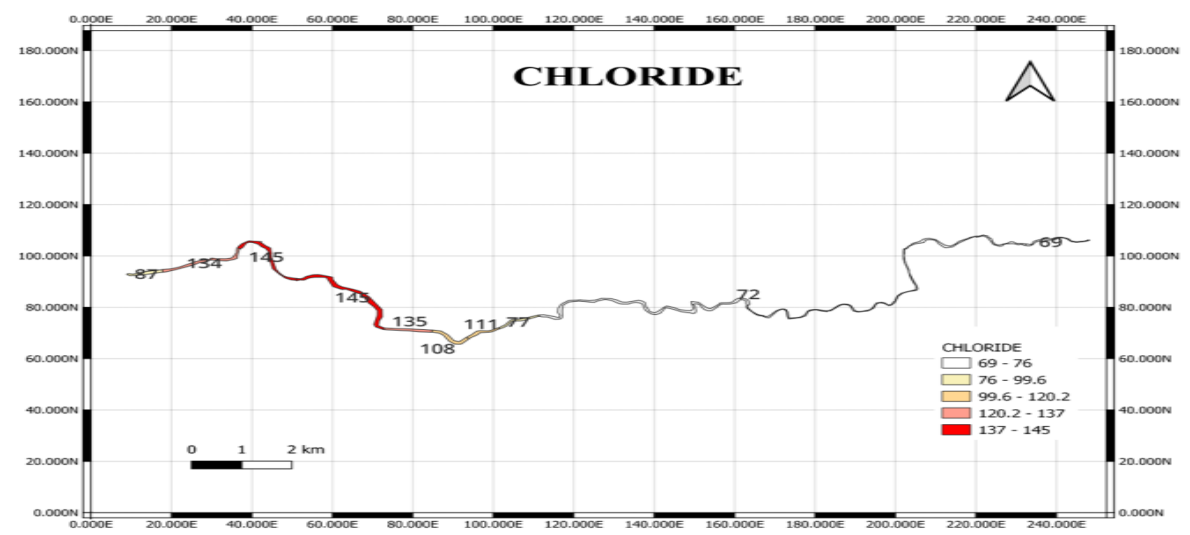
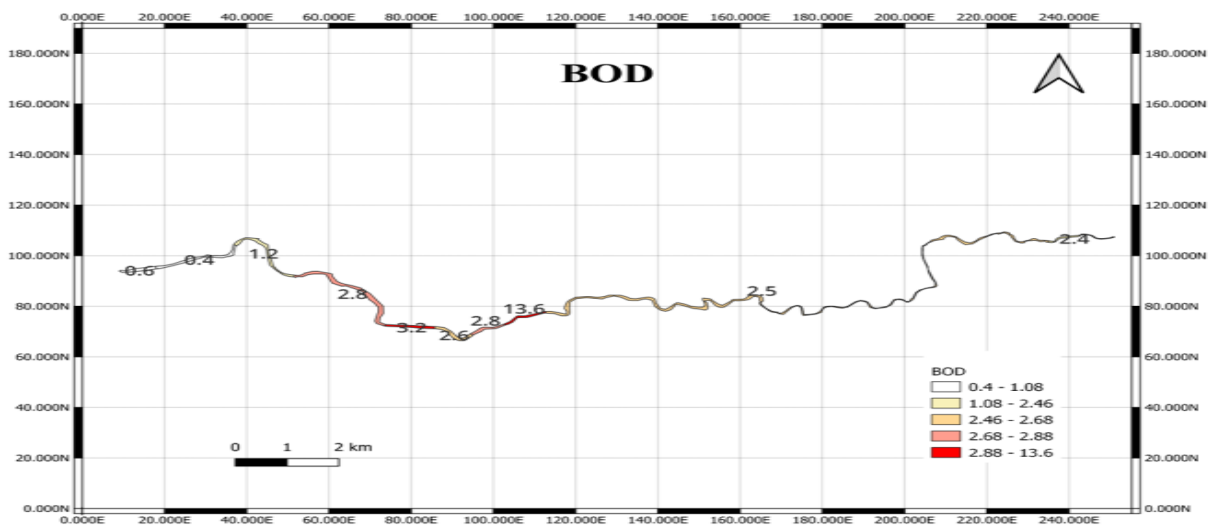
The water quality in station point 3 is very poor and that of station point 4 is fair.

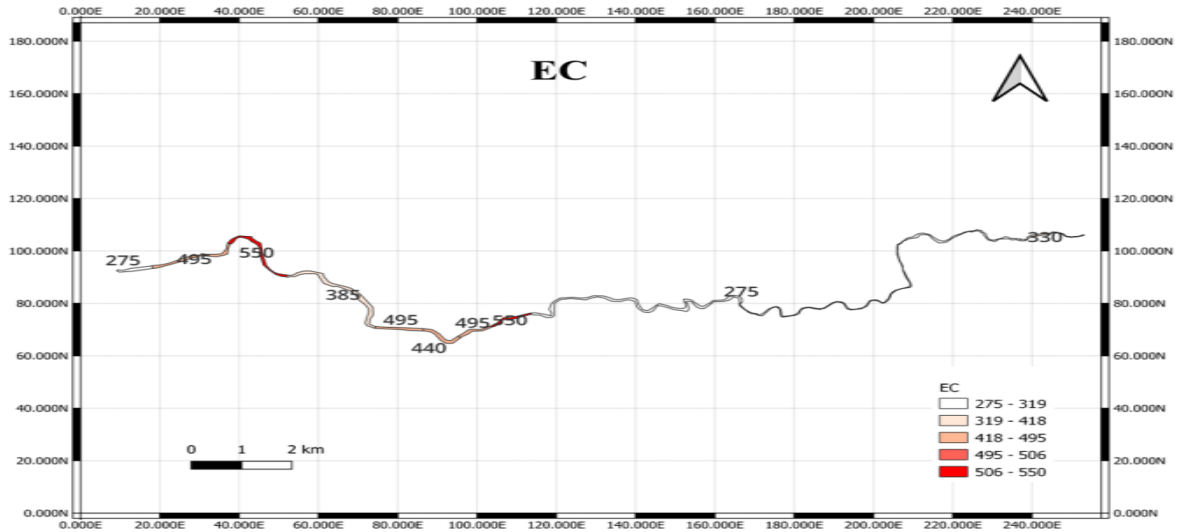
V. GIS MAPPING

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.

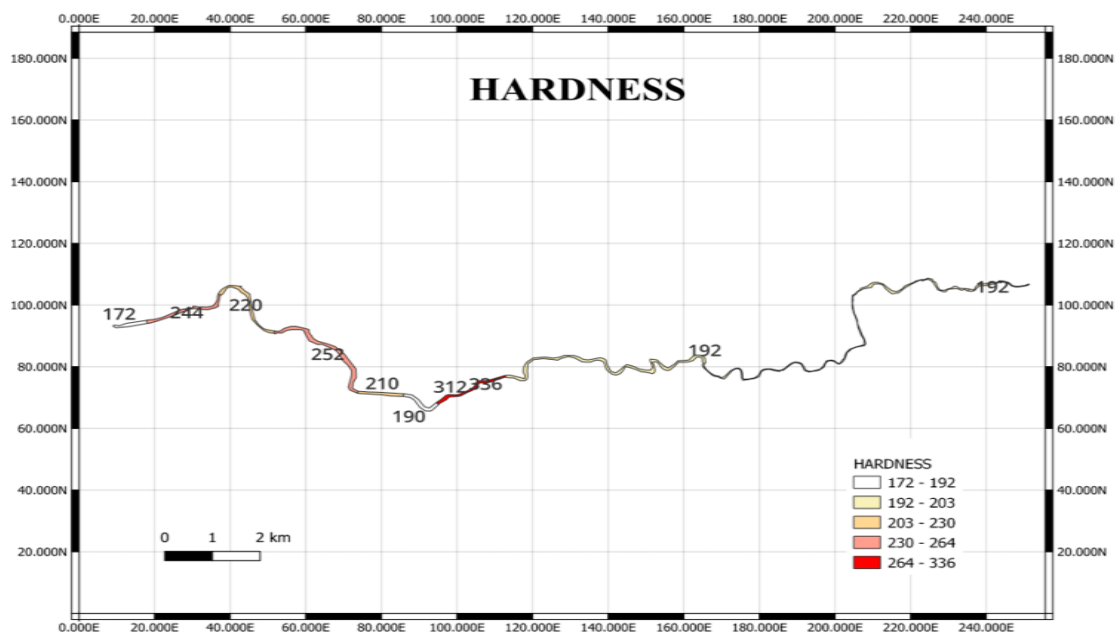
Mapping of winter season



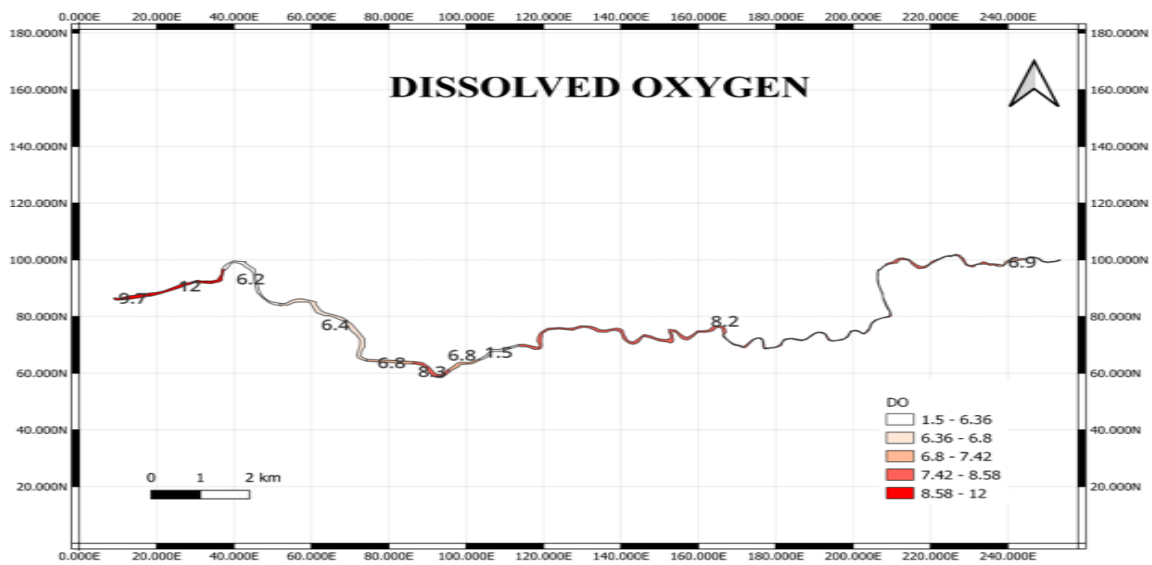
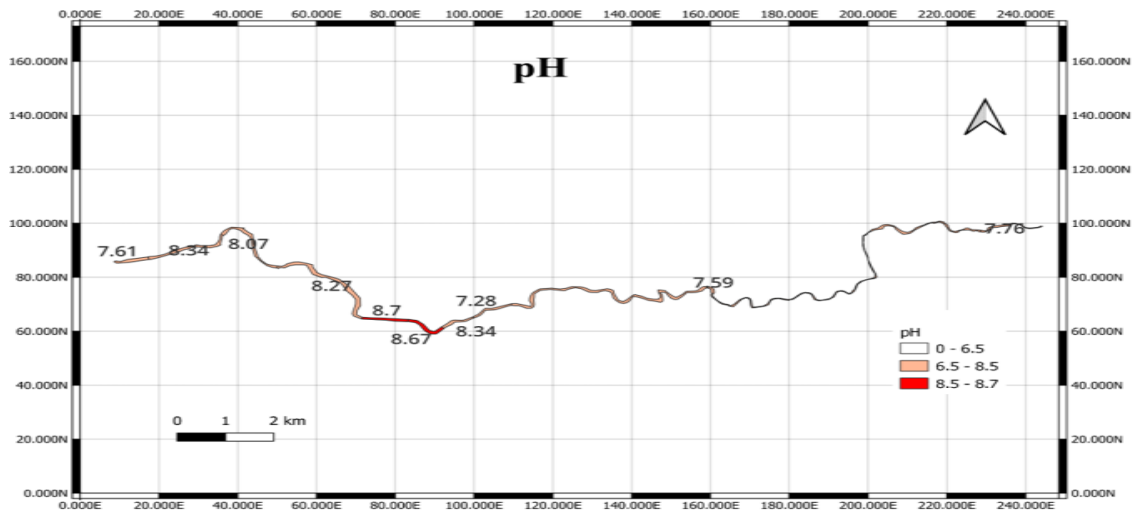


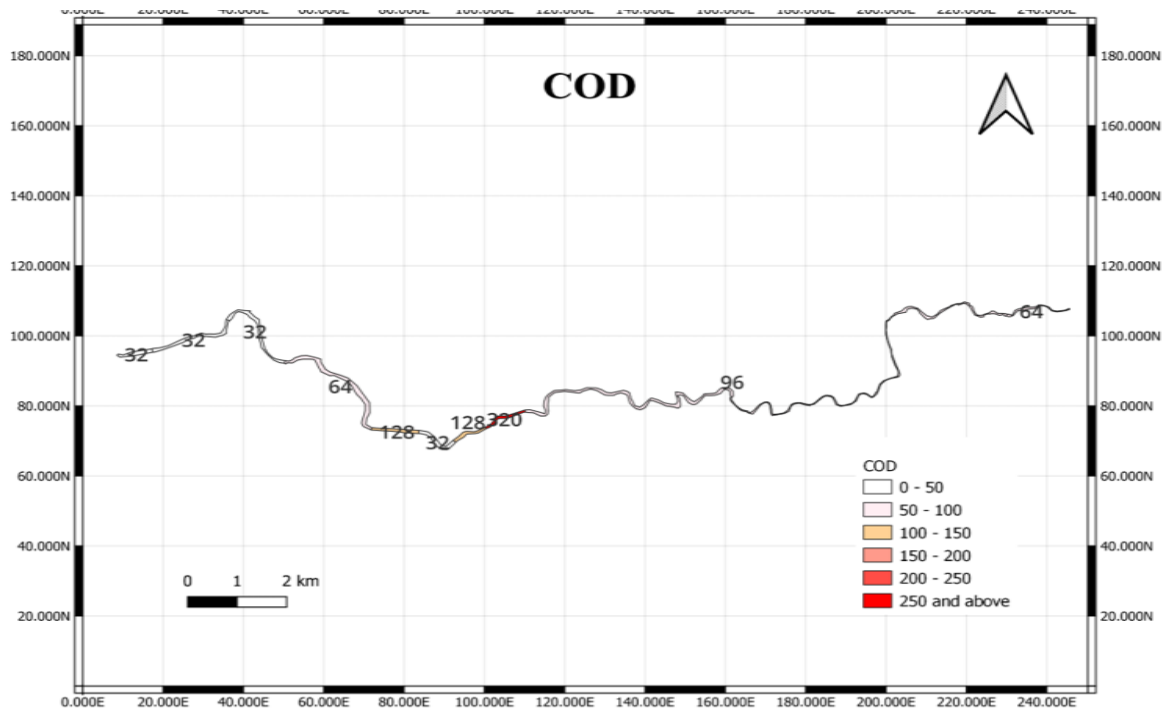
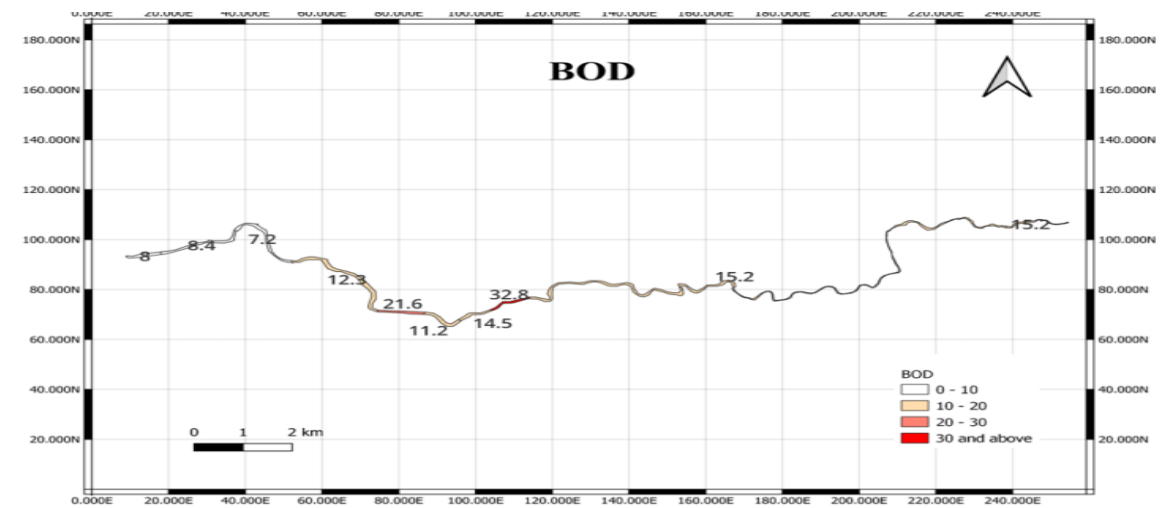
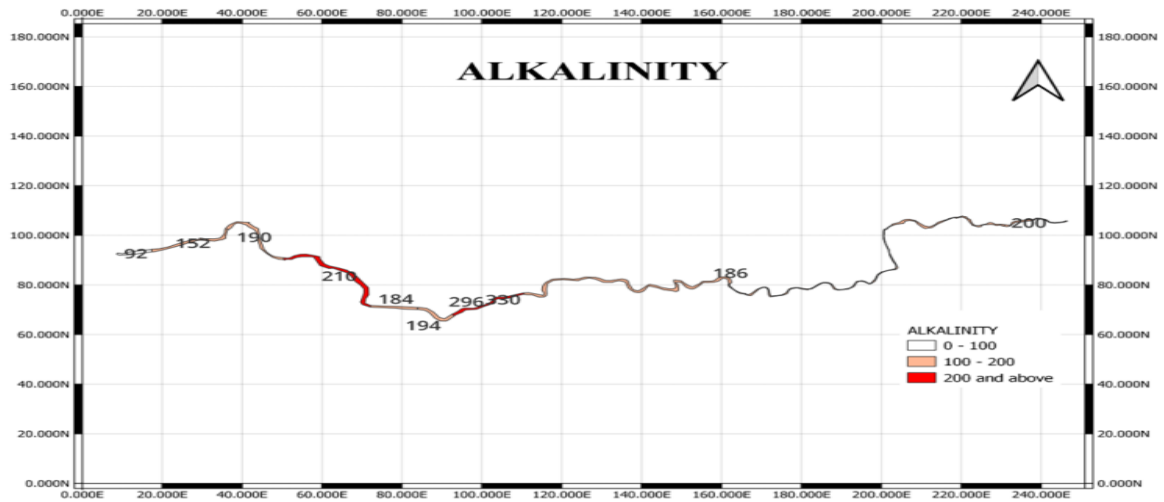


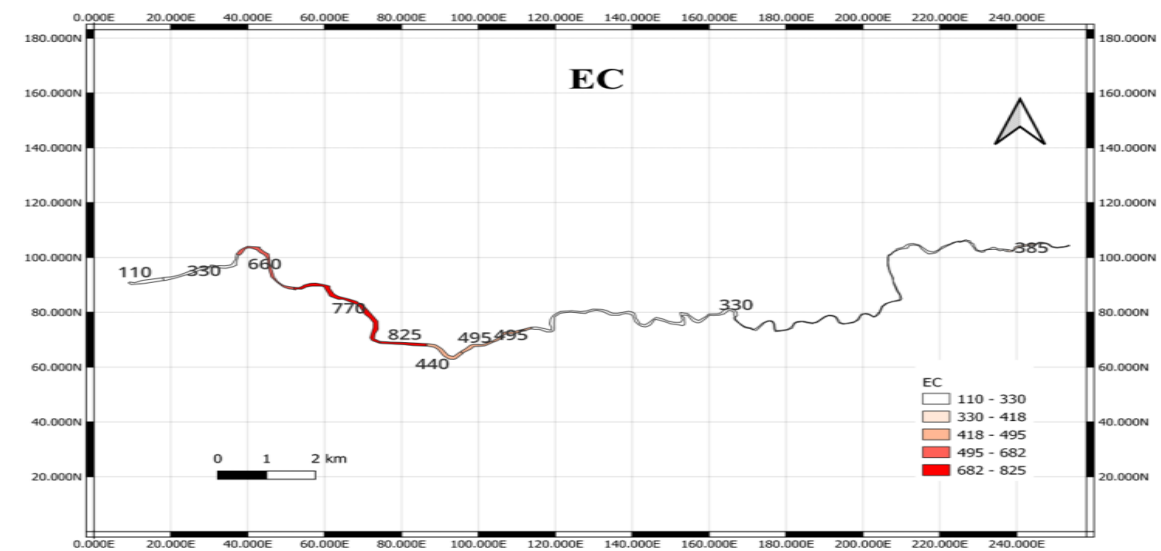
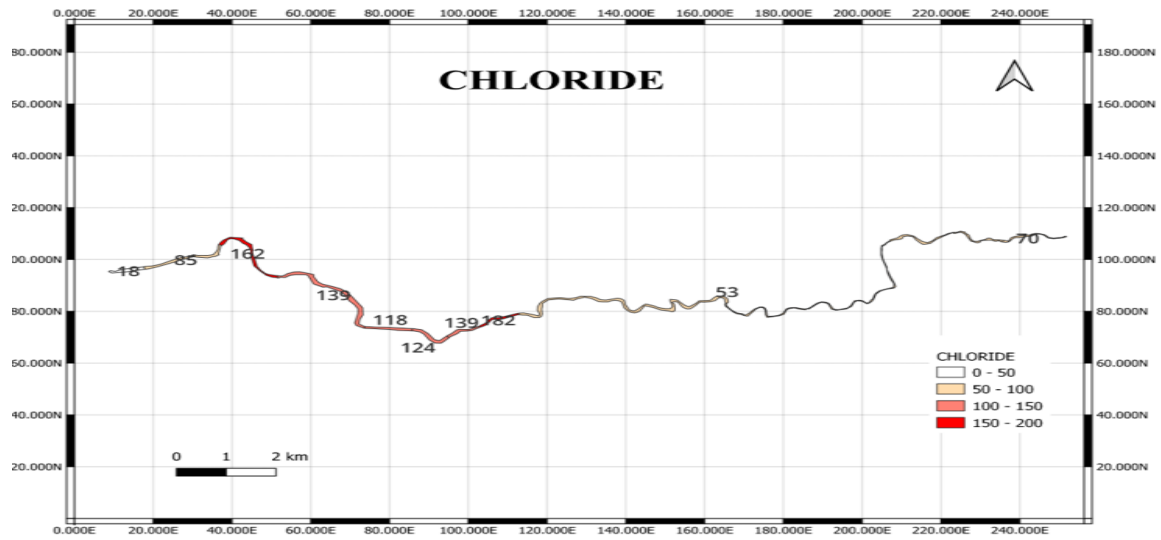
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Mapping of summer season









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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