Surface Water Quality Assessment of River Moyar In Thengumarahada Forest With GIS Applications

G.Karthikeyan[1] , Dr.J.Jeyanthi[2] , S. Abdul Rahaman[3]
[1, 2] Government College Of Technology
[3]BharathidasanUniversity

Abstract- *The quality of available water is essential to sustain life forms and furthermore is significant for sustaining a healthy vertebrate population in the forest eco-system. This spatial and temporal water quality assessment study attempts to reveal the impacts on water quality in a river system flowing inside the forestdue tohuman settlement abutting the river and also discuss whether pesticide present or not in the river system. Specifically,the quality of water was studied in regimes upstream to the human settlement representing Undisturbedforest and in regimes downstream representing disturbed forest. It was expected that the quality of water flowing downstream to the human settlement would be affected by the influx of pollutants of various forms from the humane settlement, especially by the modern agricultural chemical forms such synthetic chemicals as pesticides, fertilizers, etc., These pollutants would reflect in the water quality parameters pH, EC, TDS, the cations* Ca^{2+},Mg^{2+},Na^{+} *and* K^{+}*, as well as the anions* SO_4^{2-},Cl^{-},CO_3^{2-},HCO_3^{-},NO_3^{-} *and o-*PO_4^{3-} *and Also quality parameters such DO,BOD, and COD was determined additionally to assess the river system health. Spatial and Temporal changes in water quality assessment as well as oxygen sag curve analysis which were performed and consequently DO spatial interpolation was digitized with help of GIS application to interpret the impact of the settlement on the forest water quality.This study was carried out in the Thengumarahada settlement abutting the river Moyar flowing through the Mudumalai, Nilgiri North, and Sathayamangalam Forest Division.*

The result showed,oxygen sag curve from the end point of humane settlement and DO spatial interpolation digitized map reveals the healthy status of river Moyar. The Average temporal scale of quality parameters such COD had attend the highly variations in disturbed forest as relatively 4 times more than Undisturbed forest whereas SO_4^{2-} *and* NO_3^{-} *relatively 3 times higher whereas* Ca^{2+}, K^{+}, Na^{+},Mg^{+},HCO_3^{-}, *and* Cl^{-} *relatively 2 times higher and also* CO_3^{2-}*and o-*PO_4^{3-} *were occur in disturbed forest while these anions were nil in the Undisturbed forest*

This study reveal that modern activities inside forest have an impact and correspondingly COD, NO_3^{-} *and o-*PO_4^{3-} *variations indicates that existence of synthetic pesticides on the water quality of Thengumarahada forest streams.*

Keywords- Water quality parameters, Undisturbed forest (Undis), Disturbed forest (O), Human settlement, Synthetic Pesticides and Fertilizers.

I. INTRODUCTION

Water quality assessment in forest indicates the forest healthy assessment.People aren't the only ones who need water, animals need clean water too, Clean water is essential for ecosystems and societies worldwide.Disturbances to these ecosystems include forest harvesting, road construction and use, wildfire, insects, tree diseases, and chemical applications of fire retardants, pesticides, herbicides, and fertilizers. Other disturbances, such as the clearing of forests for mining, agriculture, or urban development, may also affect water quality (Dissmeyer (editor)2000;Kaushal et al.2006: Cretaz and Barten 2007),Water is the most vital element of all natural resources and is essential to life.It is widely recognized that sustainably managed forests play an important role in maintaining water quality.

Scientists opine that for good environment an area should have 33% of its land are under forest, but Tamilnadu has very less 20.21% only (India State of Forest Report (ISFR) 2017). Afforestation and Eco-Restoration of forest by using Natural Manure and Natural pesticides instead of using Synthetic chemicals such fertilizer, pesticides etc should be implemented to conserve the good environment in Tamilnadu state.Phenomenon of Bio-accumulation and Bio-magnification inside forest leads to Biodiversity loss.To maintain and enhance in order to achieve the paramount healthy forest, the efficient both quantity and quality wise water resources management in forest is essential,especially in Human-Animal Conflict area.The State Tamil Nadu,India has a spectrum of nine major forest types ranging from wet evergreen forest to moist deciduous, dry deciduous, sholas, grass lands and scrub forest. Thengumarahada forest has got dry thorn forest and the vegetation typegradually changes from dry thorn forest to mixed moist forests.

II. STUDY AREA

Human-Animal Conflict area of Thengumarahada comprises of forest, agriculture, domestic along with Moyarriver that flows from west to east.Semi-Arid climatic region of Thengumarahada area having two distinct seasons,the dry season which begins in March and terminates in July whereas rainy season which begins inAugustand terminates in December and this area affected by climate variability.Human settlement have been associated inside Thengumarahada forest since 200 years. Animal Husbandry and Agriculture are their major occupations. Their modern activities such mobile phone usages, plastic usages, and chemicals usages especially modern agricultural practices have been developed on last 20 years. And they have been used synthetic chemicals as Fertilizers, Herbicides, Fungicides and toxin Pesticides. The development of these chemicals inside the forest leads to biodiversity loss and affects the forest eco-system. This paper deals with impact of settlement on water quality which could be comprehended by undertaking comparison studies between two regimes and further these assessment study used as one of the reference data to proceeding the comparison studies with their down streams Bhavanisagar dam and Savandpur area.

Figure 2.1 Plan view map of Thengumarahada area

Nestled along the banks of the river Moyar, in the midst of the forest is a village named Thengumarahada(Lat 11° 33’ 57.758’’ N, Long 76° 55’ 41.8318’’ E)The village lies on the leeward side of the mountains of Kothagiri and depends on the river Moyar for the water requirements to sustain agriculture throughout the year. The river Moyar, which originates in the Nilgiri hills slithers through the forests of Mudhumalai and flows eastwards along the territorial boundary of Tamil Nadu and Karnataka. The river then flows through the Nilgiri North forests, Sathyamangalam, and eventually joins river Bhavani that drains into the Bhavanisagar dam. The river is the lifeline for numerous wildlife that resides in the forests along its banks.

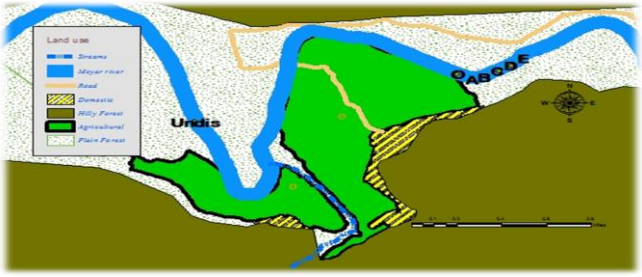

Figure 2.2 Digitized map of Thengumarahada area

Figure 2.3Moyar River

III. MATERIALS AND METHODS

3.1Field measurements

MATERIALS:

- ✓ Measuring tape and Thread
- ✓ Stick and Plastic Ball
- ✓ Thermometer
- ✓ DO meter

METHODS:

- ✓ Floating method for Velocity
- ✓ Measurement of river dimensions using measured Stick, Thread.

3.2 Sample collections

MATERIALS:

- ✓ 1 liter Plastic Water bottle (2Nos),
- ✓ 300ml BOD Bottles(7Nos),
- ✓ Marker and Carrying bag with ice.

METHODS:

Water were stirred manually at a constant depth of 0.3 m before collecting the samples, sampling bottles which were marked for proper identification

3.2.1 One liter water sample collection

Water samples during this project were taken from Moyar River at two sample points. Figure.2The first point was Undisturbed forest area (Lat 11° 34' 12.648'' N,Long 76° 54' 48.618'' E) and labeled as 'Undis'; the second point was Disturbed forest area(Lat 11° 34' 28.2'' N,Long 76° 55' 49.44'' E) and labeled as 'O',

Figure 3.1 One liter water sample collection with Labels

The water sample collected in 1 liter water bottle from these two stations 'Undis' and 'O'and would be analyzed for water quality parameters pH, EC,TDS,COD,Cations such Ca^{2+},Mg^{2+},Na^{+} and Mg^{+}, and the anions such SO_4^{2-},Cl^{-},HCO_3^{-} ,NO_3-and , o-PO_4^{3-}After these two no of 1liter water bottles collection successfully and subsequently the BOD bottles were also used for sample collection respectively.

3.2.2 BOD water sample collection

Figure 3.2 BOD water sample collection with Labels

The water sample collected in 300ml BOD bottles ,one point from Undisturbed forest(Lat 11° 34' 12.648'' N, Long 76° 54' 48.618'' E)labeled as 'Undis' andsix pointsfrom Disturbed forest(Lat 11° 34' 28.2'' N, Long 76° 55' 49.44''E), (Lat11° 34' 26.436"N, Long 76° 55' 52.8276" E),(Lat11° 34' 27.2964" N, Long 76° 55' 56.2764" E), (Lat11° 34' 29.2836" N, Long 76° 55' 56.2764" E), (Lat11° 34' 31.0908" N, Long 76° 56' 2.0076" E),and (Lat11° 34' 33.2652" N, Long 76° 56' 4.6428" E),and labeled as 'O', 'A','B','C','D', and 'E' respectively. At the'O' station for BOD sample collection about100 m spacing was given from each sample point with a time interval of ten minutes and The collected samples were refrigerated immediately after collection to avoid further degradation dueto microbial activities. Dissolved oxygen demand parameters were carried out within24 hours for accurate results.

3.3 Ex-situ analysis

MATERIALS:

- ✓ Spectrophotometer
- ✓ Flame photometer,
- ✓ BOD incubator,
- ✓ COD digester,
- ✓ pH meter,
- ✓ Conductivity meter.

METHODS:

- ✓ Ascorbic acid method for Phosphates,
- ✓ Argentometric method for Chlorides,
- ✓ Sulphanilamide method for Nitrates,
- ✓ EDTA Titration method for Hardness,
- ✓ Titration method for Alkalinity,
- ✓ Potentiometric method for pH,TDS,EC.

3.4 Sag curve model

MATERIALS:

- ✓ Microsoft Excel 2010

METHODS:

- ✓ Application of extended version of Streeter-Phelps, Thomas slope and *DD'*Connor re-aeration models respectively

3.5 Graphical representation

- ✓ ArcMap 10.3

IV. RESULTS

4.1 Part (I) Basic Water Quality & Water Healthy Parameters

TABLE 4.1(a) Basic Water Quality & Water Healthy Parameters for Undisturbed Forest Area

Station ID :'Undis' Latitude: 11° 34' 12.648'' N , Longitude: 76° 54' 48.618'' E.

Parameters/ Months	Nov	Dec	Jan	Feb	Mar	Apr	Average
pH	7.1	6.94	7	7.05	7	7.09	7.03
EC(umho/cm)	77	62	88.2	78	81	94.1	80.05
TDS(mg/L)	51.66	50.5	59.54	44.72	44.24	55.3	50.99
DO(mg/L)	8.15	8.66	8.89	8.5	8	8.24	8.41
BOD(mg/L)	0.3125	0.3125	0.9375	0.3125	0.9375	0.625	0.573
COD(mg/L)	1.5008	1.2992	1.89	2.099	2.205	2.192	1.86
Temp(°C)	21	22.5	19	20	23	23	21.42

TABLE 4.1(b) Basic Water Quality & Water Healthy Parameters for DisturbedForest Area

Station ID : 'O' Latitude : 11° 34' 28.2'' N, Longitude : 76° 55' 49.44'' E.

Parameters/ Months	Nov	Dec	Jan	Feb	Mar	Apr	Average
pH	7.78	7.55	7.69	7.55	7.19	7.2	7.49
EC(umho/cm)	129	145	169	95.5	107	179.6	137.52
TDS(mg/L)	89	110	125.566	66	74.92	106.6	95.35
DO(mg/L)	6.56	6.39	6.9	6.5	6.6	6.27	6.54
BOD(mg/L)	0.65	1.42	1.42	1.2	1.1	1.59	1.23
COD(mg/L)	4.93	5.568	6.304	3.792	3.23	5.024	4.808
Temp(°C)	22	22.5	19.5	21.8	24	25	22.47

4.1.1 Comparison studies -Part I Basic Water Quality & Water Healthy Parameters

TABLE 4.1(c)Comparison studies -Part I [TABLE 4.1(a) with TABLE4.1(b)]

PARAMETERS	DISTURBED AREA	UNDISTURBED AREA	Standards
pH	7.49	7.03	6.5-8.5
EC(umho/cm)	137.52	80.05	<1000
TDS(mg/L)	95.35	50.99	< 500
DO(mg/L)	6.53	8.40	> 4
BOD(mg/L)	1.23	0.57	Nil
COD(mg/L)	4.81	1.86	nil

4.2 Part(II) Oxygen sag curve model

TABLE 4.2 Spatial and Temporal changes in DO

Latitude	Longitude	Station name	NOV	DEC	JAN	FEB	MAR	AVERAGE
11° 34' 28.2'' N	76° 55' 49.44''E	**O**	6.56	6.39	6.9	6.5	6.6	**6.59**
11° 34' 26.436"N	76° 55' 52.8276" E	**A**	6.02	5.95	6.9	6.2	6.45	**6.304**
11° 34' 27.2964" N	76° 55' 56.2764" E	**B**	6.21	6.1	7	6.1	6.3	**6.342**
11° 34' 29.2836" N	76° 55' 56.2764" E	**C**	6.49	6.45	7.08	6.39	6.5	**6.582**
11° 34' 31.0908" N	76° 56' 2.0076" E	**D**	6.9	6.88	7.08	7.08	6.65	**6.918**
11° 34' 33.2652" N	76° 56' 4.6428" E	**E**	7.12	6.92	7.1	7.1	6.85	**7.018**

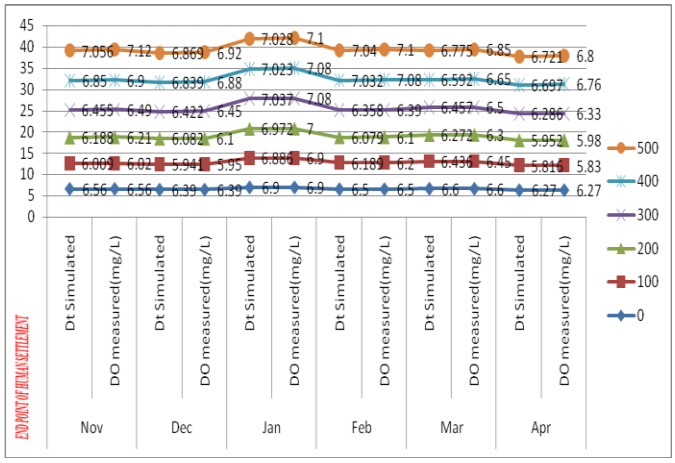

Fig.4.1 Predicted and Measured DO sag curve of Moyar River with respect to 100 m interval from End point of Human settlement on Temporral scale of (Nov 2017 – Apr 2018).

4.2.1 Comparison studies Part II DO spatial Interpolation

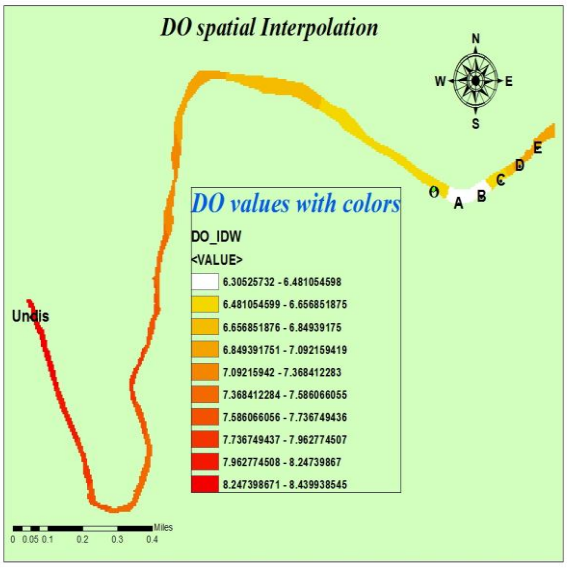

Figure4.2 DO spatial Interpolation map

4.3 Part (III) Water quality analysis of Cations and Anions

TABLE 4.3(a)Water quality analysis of Cations and Anions for Undisturbed Forest Area

Station ID :Undis Latitude: 11° 34' 12.648'' N , Longitude: 76° 54' 48.618'' E

Cations& Anions (mg/L)	Nov	Dec	Jan	Feb	Mar	Apr	AVERAGE (mg/L)
K^+	0.8	0.6	0.95	0.5	0.75	0.85	0.74
Na^+	6.15	5.8	4.85	4.9	5.8	5.6	5.52
Total Hardness	50	25	45	35	42.5	47.5	40.83
Ca^{2+}	16.016	8.008	14.014	10.01	12.012	16.016	12.68
Mg^{2+}	2.43	1.215	2.43	2.43	3.0375	7.65	3.19
CO_3^{2-}	0	0	0	0	0	0	0
HCO_3^-	18	13	32	18	16	33	21.67
Cl^-	12.496	14.99	12.496	9.996	14.99	14.99	13.32
SO_4^{2-}	1.74	2.5	2.26	3.58	3.1	2.92	2.68
NO_3-N	0.75	0.82	0.7	0.72	1.1	1.19	0.88
o-PO_4	0	0	0	0	0	0	0

***all units in mg / L

TABLE 4.3(b) Water quality analysis of Cations and Anions for Disturbed Forest Area

Station ID : 'O' Latitude : 11° 34' 28.2'' N, Longitude : 76° 55' 49.44'' E.

Cations& Anions (mg/L)	Nov	Dec	Jan	Feb	Mar	Apr	AVERAGE (mg / L)
K^+	1.6	2.3	2.3	0.5	0.85	1.4	1.49
Na^+	10.92	14.78	15.9	6.53	6.9	10.855	10.98
Total Hardness	120	60	95	90	65	92.5	87.08
Ca^{2+}	42.042	20.02	30.03	30.03	17.017	31.031	28.36
Mg^{2+}	3.645	2.43	4.86	3.645	5.4675	14.936	5.83
CO_3^{2-}	2	1	0	0	0	0	0.5
HCO_3^-	34	24	53	25	26	53.5	35.92
Cl^-	29.991	32.49	19.994	14.99	19.994	24.992	23.74
SO_4^{2-}	7.7	10.76	11.1	4	3.5	4.3	6.89
NO_3-N	2.43	2.985	2.69	1.45	1.87	1.75	2.19
o-PO_4	0.024	0.1	0.06	0	0	0.01	0.032

**all units in mg / L

4.3.1 Comparison studies -Part III Water quality analysis of Cations and Anions

TABLE 4.3(c) Comparison studies -Part III [TABLE 4.3(a) with TABLE 4.3(b)]

Cations& Anions	DISTURBED AREA (mg /L)	TIMES	UN DISTURBED AREA (mg /L)	Standards (mg /L)
K^+	1.49	**2.01**	0.741	<10
Na^+	10.98	**1.99**	5.51	<20
Ca^{2+}	28.36	**2.24**	12.68	<75
Mg^{2+}	5.83	**1.82**	3.19	<30
CO_3^{2-}	0.5		0	
HCO_3^-	35.90	**1.66**	21.67	<300
Cl^-	23.74	**1.78**	13.33	<250
SO_4^{2-}	6.89	**2.57**	2.68	<200
NO_3-N	2.19	**2.49**	0.88	<10
o-PO_4	0.032		0	

***all units in mg /L

V. DISCUSSION OF RESULTS

From the laboratory results[Table 4.1(a),4.1(b),4.3(a),4.3(b)]for every month between the November 2017 and April 2018,the quality of water which were collected at the disturbed and Undisturbed regimes represented by [Table 4.1(c)] the average values of the water quality parameters such as pH, EC, TDS, and[Table 4.3(c)] the average values ofthe cations Ca^{2+},Mg^{2+},Na^+ and Mg^+, as well as the anions SO_4^{2-},Cl^-,HCO_3^-,NO_3-, and O-PO_4^- and also[Table 4.1(c)] the average values of water healthy parameters such DO,BOD,COD.

SulphatesandNitrates relatively three times higher in Human settlement area than Non-human settlement area whereas Sodium, Magnesium, Bi-carbonates, Chlorides, Potassium and Calcium relatively two times higher and also Carbonates and Phosphates were occur in Human settlement area (Disturbed forest)while these two anions were nil in Non-Human settlement area(Disturbed forest). Principally Carbonates occurs in the months November and December whereas Phosphates occurs in the months November, December,January and April.

These water quality spatial variations including TDS,DO,BOD spatial variations between Undisturbed(Lat 11° 34' 12.648'' N,Long 76° 54' 48.618'' E) and Disturbed(Lat 11° 34' 28.2'' N,Long 76° 55' 49.44'' E) regimes of Thengumarahada forest exposed the manifestation of settlement impact on forested water quality and also DO spatial variation from the end point of human settlement area are also confirmed the manifestation of settlement impact on forested water quality.Correspondingly COD, Nitrates, Sulphates variations and also specifically presence of phosphates in disturbed forest while there is nil phosphates in the Undisturbed forest[Table4.1(c)&4.3(c)] indicates that existenceof toxin Pesticides Monocrotophos($C_7H_{14}NO_5P$) and Dimethoate($C_5H_{12}NO_3PS_2$) in the river Moyar,Thengumarahada forest.

VI. CONCLUSIONS

In conclusion,Human habitat chemicals(Agricultural chemicals,soaps,detergents,etc) moderately affects the Thengumarahada forested water quality. Especially from the agricultural field Synthetic chemicals of Fertilizers, Pesticides and Fungicides such major chemicals plays main role. Only Fraction of Nitrogen based fertilizers is converted to produce and plant matter,reminder accumulates in the soil or loss as run off. High use of fertilizers could leads to soil acidification,accumulation of toxic elements such Cadmium, Fluoride, Radioactive elements,etc.,and They may cause

breakdown of the symbiotic relationships between plant roots and mycorrhizal fungi and thus they changes in soil biology.Here should noted that,about 80% of vascular plants worldwide form symbiotic relationships with fungi.On high usages of synthetic fertilizer(while manufacturing also) produces such green house gases Nitrous oxide,and Methane. Consequently they affects the Bio-geochemical cycles of the forest.

Synthetic chemicals of Pesticides, Herbicides, Fungicidesare responsible to destroyed the natural organisms such as bees, earth worms, frogs, herons, dragon flies and birds like Sparrow were reduced in numbers.Phone radiation and plastic usages might be contributed in this activity.On high usages of synthetic pesticides leads to Bio accumulation and Bio magnification which subsequently leads to Bio-diversity loss in the forest.

It can be concluded that the water quality at human settlement areas were moderately degraded than Undisturbed forest and existence of Organo phosphate pesticides in Moyar river,Thengumarahada forest could be and also forest species in agricultural area diminish, that indirectly tells that biodiversity of Thengumarahadaforest eco-system impaired. However research must be expanded and strengthened to improve our understanding of biodiversity and its potential role in building sustainable forest and human societies.

On completion of about 20 years and further prolongation of these modern activities inside the forest which could affects the forest ecosystem.

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