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Sustainable Restoration and Management of the Noyyal River: Addressing Environmental Challenges and Water Pollution Control

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ABSTRACT:

The Noyyal River, a tributary of the Cauvery River in Tamil Nadu, was once a crucial source of water for drinking, agriculture and ecology. But fast urbanization and industrialization, especially the increase of dyes and bleach industries in Coimbatore since the late 1980s have resulted in excessive contamination of water. The dumping of untreated industrial effluents, domestic sewage and solid waste into the river has led to the deterioration of the water quality, rendering it unsafe for irrigation and human use. This report investigates the reasons behind water pollution in the Noyyal River, its impacts and current status, while also analysing governmental and judicial responses, including Zero Liquid Discharge policies (ZLD) and Common Effluent Treatment Plants (CETPs).

In order to ensure that future water supply can continue and be used sustainably, the Noyyal River needs to be restored through a combination of approaches. To combat pollution effectively we need enforceable environmental laws, traditional tank systems, community involvement, and a variety of regulatory mechanisms. This will help create a sustainable ecological environment and water resource stability.

KEY POINTS: Noyyal River, Cauvery River, Zero Liquid Discharge(ZLD), Common Effluent Treatment Plants(CETPs), River restoration models, Dyeing and Bleaching units, Water pollution, sustainable ecology , resource stability.

INTRODUCTION:

The Noyyal River rises in the Vellingiri Hills (Western Ghats) near Kovai Kutralam. After winding for about 180Km, it flows through the Coimbatore, Tiruppur, and Erode districts and finally joins its tributary Cauvery River at Kodumudi. Its major tributaries are Chinnar, Kanchimanadhi, and Nallaru Origin: 10° 58.242′ N 76° 43.998′ E.

At one time the Noyyal River was a source of agricultural, cultural and economic support to the people living in Western Tamil Nadu, but this has changed since the late 1980's early 1990's when an increase in textile dyeing and bleaching plants located around the city of Tiruppur resulted in the large amount of pollution being dumped into the Noyyal River. Industrial waste such as wastewater (including dyes, toxic chemicals, surface runoff water and groundwater), in addition to soil contamination are other examples of extensive pollution occurring on a continuing basis to this river; even when CETPs (Common Effluent Treatment Plants) and ZLD (Zero Liquid Discharge) systems are available due to their high cost, poor maintenance, and therefore only partially implemented. The restoration of the Noyyal River can only be realized via an increase in regulatory enforcement, advancements in technology, and broader public engagement in the restoration efforts of the river.

Water samples were taken along a 15 km stretch of the river and nearby wells to check pollution levels. Water quality evaluations and pollution spread utilization were based on Water Quality Index (WQI), GIS-based inverse distance weighting (IDW) analysis and correlation with Statistical Package for the Social Sciences (SPSS).

I. AIM:

This paper assesses the ecological impacts of Noyyal River pollution in Coimbatore, based on systematic scientific scrutiny of surface and groundwater quality. It seeks to formulate efficient measures that can lead to, improvement of water quality, reduction of contamination and enhanced pollution control methods conducive for sustainable river basin management and environmental resilience.

Er. I. Subiksha obtained her bachelor's and master's degrees in urban planning fromKarpagam Academy of Higher Education. Academic training equipped her with asound understanding of the principles of urban planning, land use regulations, and theneed to balance urban development with environmental and heritage conservation.This report is based on the academic work completed by Subiksha as a reference forthis research study.

Er. K. Rupashree earned a Bachelor's degree in Civil Engineering along with aMaster's degree in Town & Country Planning from Karpagam Academy of HigherEducation, resulting in a robust base in Urban Planning Principles, Land UsePlanning, as well as balancing the need for infrastructure development andenvironmental sustainability. Her education combines engineering perspectives withPlanning resulting in a well-rounded approach towards designing and planning UrbanSpaces consistent with Sustainable Development Goals (S.D.G.).

Er P. Sasikumar is a veteran GIS specialist and urban planner, having worked onmultiple national-level planning programs. He has been a faculty in the Departmentof Planning at Karpagam Academy of Higher Education since 2010. He is a Graduatein Engineering from Coimbatore and a Postgraduate in M.Plan (Town and CountryPlanning), Anna University, Chennai. His research interests consist of sustainableurban development and enviromental assessment and doctorate in Civil Engineering.

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II. OBJECTIVE:

1. To pick the major sources of water pollution in the Noyyal River, including industrial, domestic, and agricultural discharges.
2. To scrutinize the physico-chemical and biological characteristics of the river water and grade them based on standard water quality guidelines.
3. To appraise Effluent Treatment Plants (CETPs) and Zero Liquid Discharge (ZLD) systems executed in the Coimbatore industrial region.
4. To assess environmental and socio-economic impacts of river pollution on local communities, agriculture, and aquatic ecosystems.
5. To map pollution hotspots and study spatial variations in contamination along the river course using scientific data and field observations.
6. To endorse effective control and restoration measures for improving the river's water quality and promoting sustainable water management practices.

III. BACKGROUND OF THE STUDY:

Located at the bottom of the Western Ghats along the Noyyal River, Coimbatore is large and has many commercial/industrial sectors. The river has also helped supply water to the Kongu area through underground reservoirs, so it is a very important part of life in the area. Historically, the Chola and Nayak kings created large tank irrigation systems to provide water for agriculture.

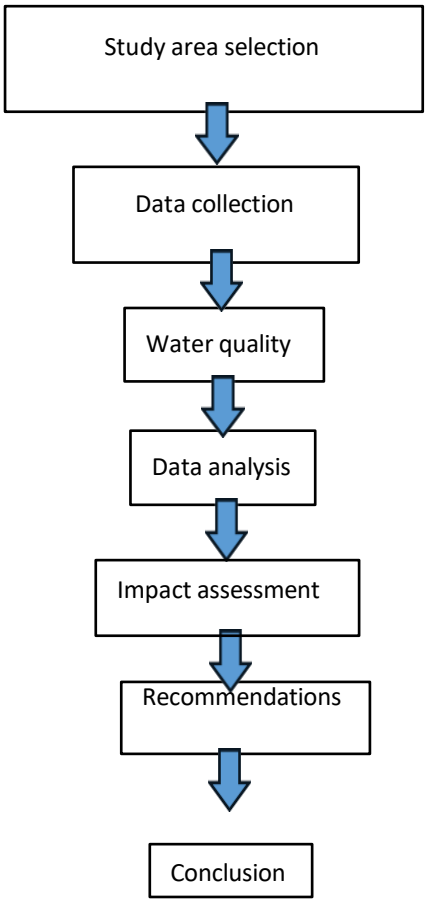
Cultivation was abundant due to the alluvial soil in the plains near the Noyyal. In addition, the Noyyal River was essential to establishing temple towns and creating cultural landscapes.Unfortunately, over the past few decades, rapid expansion of Coimbatore urban area and industrialization of Tiruppur have caused much ecological damage to the river. The Orathupalayam Dam in 1992 built originally for irrigation purposes has turned the reservoir into a containment site for untreated textile dyes waste water.

Indiscriminate release of such effluents along with agricultural runoff has resulted in decreased discharge of the Noyyal River, and increased degree of pollutants as indicated by high levels of COD and BOD.

Water supply to surrounding aquifer has been ruined due to contamination. Measurements over time show that the quality of both surface and groundwater have diminished resulting in extremely high TDS levels, extensive alkalinity, and excessive amounts of total hardness.

An extensive assessment of water quality was conducted on a fifteen-kilometre stretch along the Noyyal River from Ondipudur to Sulur Lake, where surface samples were taken from four sampling sites along the river and compared to the control water samples collected from Boluvampatti (upstream of Coimbatore) and Kasipalayam (downstream of Tiruppur).

IV. METHODOLOGY:



V. STUDY AREA

Coimbatore in Tamil Nadu is one of the top ten urban areas of India as ranked by population, and the second largest in Tamil Nadu. The development of the city as a significant economic centre has been primarily due to its rich cultural heritage, significant industrial growth and world-class educational facilities. Surrounded by the Western Ghats and the Noyyal River basin, it is no surprise that Coimbatore's economic growth emerged from regions where agriculture was initially established, both in terms of settlement patterns and water use. Weather conditions in Coimbatore are highly supportive of comfortable living, with average temperatures ranging between 20–30 °C, contributing to a high quality of life for residents.

Coimbatore has an exceptional mix of traditional and modern cultures as a result of the influence of both rural and urban elements which makes it a popular place for persons to relocate.

Environmental degradation has emerged as an ever-rising threat to ecosystems including the Noyyal River and its tributaries leading to very poor water quality in the Coimbatore region for the past several decades. Unfortunately due to heightened surges in human activity, an overwhelming amount of pollution is being introduced through improperly treated industrial waste and agricultural runoff.

This study evaluates a 15 k m portion of the Noyyal River that runs from Ondipudur down to Sulur Lake, identified by means of an initial reconnaissance survey. Water samples were obtained from four sampling points along the study stretch; these were Ondipudur, Irugur, Ravi Malai, and Sulur Lake. Also samples were taken from Boluvampatti (basin, at upper end of river before reaching Coimbatore's limits), and Kasipalayam (basin, at lower end of river after passing full length of Coimbatore).

Surface water quality analysis followed IS 10500:2012 and supported previous studies regarding surface water quality; surface water quality was assessed using the following parameters: pH, TDS, BOD, COD, hardness, alkalinity, appearance, odour, colour, turbidity, EC, Mg, Cl, Na, NO2, sulphate, CaCO, K, and (E. coli) Escherichia coli count; selected parameters: colour, pH, alkalinity, hardness, chloride, TDS, fluoride, magnesium (Mg), sodium (Na), nitrite (NO2), calcium (Ca), potassium (K), and EC; quantification of pollution; to see if there are differences between groundwater and surface water; identifying major factors affecting the quality of water within the Noyyal River watershed.

VI. DATA COLLECTON FROM RTWQMS:

The most recent monitoring data (June 2025) from the Tamil Nadu Pollution Control Board's Real-Time Water Quality Monitoring System (RTWQMS) and follow-up hydrological studies indicate that the Noyyal River is still polluted far above acceptable standards at a number of sampled sites.

Sample collection:
Types of sample collection:

1. Grab Sampling

Grab samples are also known as catch or spot samples. Grab samples are single samples taken at a specified location and time. Samples should only be taken when the source has a consistent composition over time and may be horizontal or vertical variation. Grab sampling was the method for sample collection in the research study for water quality.

2. Composite Sampling

Complex liquid matrices that alter with time, depth, or location use parameters such as pH, BOD, COD, TDS, TSS, and electrical conductivity at designated stations along its length, from Coimbatore to Orathupalayam.
Composite sampling, was done at 1-3-hour intervals for 24 hours.

3. Integrated Sampling:

Integrated sampling is carried out by collecting mixture of grab samples collected from different points simultaneously. The points may be horizontal or vertical variation. Grab sampling was the method for sample collection in the research study for water quality.

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TABLE 1: STATUS OF WATER AT VARIOUS PLACES

S.no	Parameters	Permissible limit(BIS/WHO)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Inference
1	pH	6.5-8.5	8.8	9.1	9.3	9.34	9.42	Slightly acidic near industrial areas
2	TDS	500-2000mg/l	2158	2036	2363	2871	2963	Salinity due to dyeing effluents.
3	BOD	30mg/l	41	46	53	59	102	High organic load from sewage discharge
4	COD	250mg/l	268	298	279	397	631	Cleanly explains sever chemical contamination
5	Hardness	300-600mg/l	893	925	1218	1396	3216	Textile dyeing units that discharge water rich in salts and chemical compounds
6	Alkalinity	200mg/l	256	279	314	329	712	Industrial contamination
7	Appearance	-	Turbidity	Turbidity	Turbidity	Turbidity	Turbidity	Durty and unclean
8	Odour	Agreeable	Not Agreeable	Not Agreeable	Not Agreeable	Not Agreeable	Not Agreeable	Unbearable smell
9	Colour	-	Greenish Yellow	Greenish Yellow	Greenish Yellow	Greenish Yellow	Yellow	Nutrient enrichment, dye effluents, and reduced self-purification.
10	Turbidity	1-5NTU	38	40	32	36	79	Presence of suspended particles such as clay, silt
11	Electrical conductivity(EC)	500-1000 umhos/cm	1531	1952	2123	2296	3124	Indicator of ionic and chemical pollution in water.
12	Magnesium(Mg)	30-100mg/l	157	163	169	187	369	The presence of high magnesium levels in water indicates chemical contamination, mainly from industrial effluents
13	Sodium(Na)	30-60mg/l	66	71	82	87	115	Chemicals increase salinity, alkalinity, and hardness, making the water unsuitable for irrigation and drinking.
14	Potassium(K)	12mg/l	48	53	71	72	106	Nutrient imbalance, health risk for kidney/heart patients, increased TDS
15	Nitrite(NO_2)	50mg/l	66	69	73	85	131	Toxic to humans and fish
16	Chloride(Cl)	250mg/l	247	285	312	356	591	Salty taste, corrosion, soil salinization, crop damage, aquatic stress
17	Sulphate(S)	200-400mg/l	135	168	196	354	569	Laxative effect, soil acidification, corrosion, aquatic toxicity
18	Calcium Carbonate	75-200 mg\l	182	192	203	229	291	Soil alkalinity and decline in crop productivity in nearby farms.
19	E-Coli (Escherichia Coli)	-	52	63	67	83	113	Water-borne diseases, oxygen depletion, unsafe irrigation

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VIII. WATER QUALITY REMARK:

Water quality index (WQI)

The weighted arithmetic method is used to calculate the water quality index.

The Water Quality Index (WQI) is a numerical value that is used to assess the quality of water by integrating a number of different criteria into a single value. This number reflects the overall state of the water and may be used to determine whether it is suited for drinking, recreation, and maintaining ecological health. Miscellaneous qualities, together with physical, chemical, and biological markers, were used in the WQI as the basis.

WOI - WI QI/EW

where n represents the number of variables or parameters, Wi denotes the unit weight for the ith parameter, and Qi denotes the quality rating (sub-index) of the ith parameter. The unit weight (Wi) of the various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters.

Wi-K/S
K-1/2 (1/50)
Quality Rating
Qi-100[(Vo-Vi)/(Sn-Vi)]

If, Qi0-absence of contaminants

Qi<100-contaminants are within the prescribed standard. Qi 100 contaminants are above the standards.
(Wi) The unit weight of the various water quality parameters.
Qi-quality rating (sub-index) of the ith water quality parameter.
SnBIS standards Vo
Ideal value
VnMean condition value (testing report value).

TABLE 3: RANGE OF WATER QUALITY INDEX (WQI)

WQI	RATING
0-25	Excellent
25-50	Good
50-75	Poor
75-100	Very poor
>100	Unsuitable for Drinking

TABLE 4: SHOW THE WQI CALCULATION RESULTS OF SAMPLES

SAMPLE	WQI	RATING
1	76.95	Very poor
2	420.81	Unsuitable
3	450.73	Unsuitable
4	418.51	Unsuitable
5	456.07	Unsuitable
6	866.82	Unsuitable

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TABLE 2 : SHOWS THE CALCULATION OF WATER QUALITY INDEX (WQI) .

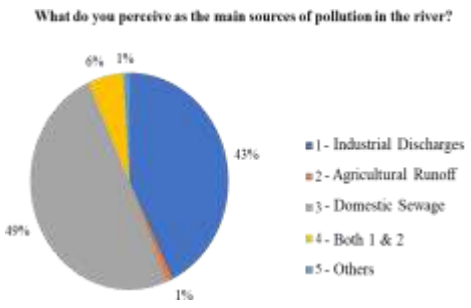
Parameter	BIS Standard(sn)	1/sn	Sum of (1/sn)	K=1/sum of (1/sn)	Wi=k/sn	Ideal value(Vo)	Mean con.Value (Vn)	Vn/Sn	Vn/Sn* 100=Qi	WiQi
Ph	8.5	0.118	0.505	1.980	0.233	7	8.8	1.200	120.000	27.956
TDS	2000	0.001	0.505	1.980	0.001	0	2158	1.079	107.900	0.107
BOD	30	0.033	0.505	1.980	0.066	0	41	1.367	136.667	9.021
COD	250	0.004	0.505	1.980	0.088	0	268	1.072	107.200	0.849
Hardness	600	0.002	0.505	1.980	0.003	0	893	1.488	148.833	0.491
Alkalinity	200	0.005	0.505	1.980	0.010	0	256	1.280	128.000	1.267
Turbidity	5	0.200	0.505	1.980	0.396	0	38	7.600	760.000	300.990
Electrical conductivity(EC)	1000	0.001	0.505	1.980	0.002	0	1531	1.531	153.100	0.303
Magnesium(Mg)	100	0.010	0.505	1.980	0.020	0	157	1.570	157.000	3.109
Sodium(Na)	60	0.017	0.505	1.980	0.033	0	66	1.100	110.000	3.630
Potassium(K)	12	0.083	0.505	1.980	0.165	0	48	4.000	400.000	66.007
Nitrite(NO2)	50	0.020	0.505	1.980	0.040	0	66	1.320	132.000	5.228
Chloride(Cl)	250	0.004	0.505	1.980	0.008	0	247	0.988	98.800	0.783
Sulphate(S)	400	0.003	0.505	1.980	0.005	0	135	0.338	33.750	0.167
Calcium Carbonate	200	0.005	0.505	1.980	0.010	0	182	0.910	91.000	0.901
E-Coli	0	0.000	0.505	1.980	0.000	0	52	0.000	0.000	0.000
		0.505			1.00				WQI	420.809

IX. DATA ANALYSIS:

Statical correlation is a way to measure and look at how vigorously two factors interact. Correlation analysis focuses to determine how the two are related to each other .

Methods of studying correlation

1. A scatter diagram
2. Karl Pearson's Correlation Coefficient
3. Spearman's rank correlation coefficient
4. Method of least squares



IMPACT ASSESSMENT

Findings from the PHC Survey show that water quality parameters exceeding acceptable limits have adverse impacts on health for PHC residents. Poor water quality is associated with the following health issues:pH - gastrointestinal problems including discomfort, irritations to the skin; total dissolved solids – upset stomach, vomiting, diarrhoea, irritation to skin; total dissolved solids – upset stomach, vomiting, diarrhoea, and irritation to the skin; hardness/alkalinity – problems with hair, skin irritation and gastrointestinal problems; fluoride – effects on tooth enamel and issues with the bones; magnesium/sodium – effects on the tooth enamel; vomiting and high blood pressure issues; nitrate, calcium and potassium - are all associated with issues with bones; skin irritations, and gastrointestinal disturbances; EC, BOD, COD – increased risk of water-borne diseases e.g., typhoid fever and cholera.

X. RECOMMENDATION:

To protect and restore river water quality, strict industrial regulations and regular water monitoring should be enforced. Public awareness about clean water and responsible waste disposal must be increased. Adopting zero discharge systems, proper solid waste management, and restoring riparian zones with native vegetation are essential. Additionally, promoting eco-friendly farming practices and bioremediation techniques can help naturally reduce pollution and improve river health.

Restoration strategies and technologies

Restoration strategies and technologies require a mix of prevention, engineered treatment and nature-based remediation tailored to source and media; examples in the basin include Zero Liquid Discharge (ZLD) adoption and pilot phytoremediation. Approaches should prioritize source elimination, decentralized treatment and phased remediation of soils and groundwater.

Examples of Technology or approach Mechanism used in Noyyal basin

Zero Liquid Discharge (ZLD) Recycles/evaporates processed effluent to eliminate discharge-Adopted by Tiruppur textile units since ~2013 and reduced the effluent volumes entering the basin. Advantage- Eliminates direct effluent discharge; Limitation-high cost and concentrated solids require proper management.

Phytoremediation (Aloe vera, Typha) Plants absorb/transform metals and organics in water/sediments. Pilot studies report reductions in BOD/COD and metals over short trials with Aloe vera and Typha spp. Advantage- Low cost and locally deployable.
Limitation-Mostly pilot-scale evidence and is slower process for deep contamination

Conventional physicochemical treatment

Coagulation, advanced oxidation and sedimentation are certainly approved methods of remediation for basin scale (however typically use limited to individual sites), yet they are also associated with high costs and overall complexity when examining{emphasis added) the basin scale; thus used primarily to clean up specific areas, not riverwide.

Integrated sequencing Prioritize

(1) source control (ZLD, bans),
(2) decentralized treatment for urban sewage,
(3) riverbank/constructed phytoremediation in hotspots, and
(4) long-term soil and groundwater remediation where contamination persists

Pollution control methods and treatment approaches

Practical control requires mixing regulatory, centralized and decentralized technical solutions, plus targeted remediation of contaminated soils and aquifers. Monitoring and adaptive operation determine effectiveness.
Source control and industry measures enforce discharge bans, uniform adoption of ZLD where feasible, and cleaner production practices in textile processing to reduce pollutant loads at the origin .

Nature based remediation Use riparian planting, floating treatment wetlands and targeted phytoremediation (Aloe vera, Typha) in affected stretches as low-cost, community-implementable steps shown to lower BOD/COD and metal concentrations in trials
Treatment for concentrated wastes manage ZLD residues and sludge safely; apply appropriate physicochemical or advanced treatments where rapid removal is required, acknowledging higher costs.

XI. CONCLUSION:

The Noyyal River has several areas where pollutants are at their highest, namely between Tiruppur and and Orathupalayam. Notably, lead, chromium and TDS levels far exceed those acceptable for drinking water and irrigation purposes. Industrial waste has been curtailed through the use of Zero Liquid Discharge (ZLD) and Common Effluent Treatment Plant (CETP) initiatives. However, the negative impacts of sewage leakage and heavy metal sediments will pose an ongoing threat to the river's ecological and human safety. Collectively, this research will assist in establishing guidelines for improved water management and controlling water pollution in the Noyyal River. Furthermore, the findings will assist in reducing pollution and increasing the quality of water in the Noyyal River for all types of people who use it daily, such as farmers and businesses that depend on it to make their living and the ecosystems and communities that rely on it for survival. In addition, the results produced by this research may assist in preventing or possibly correcting the damage that has been done to the Noyyal River over many years.

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