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The Ecological Crisis of the Noyyal River: A Comprehensive Analysis

V. Johnpaul*, Venkatesan Govindaraj[1] and A. Mohanarathinam[2]

Department of Civil Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India
[1]Department of Civil Engineering, Saveetha Engineering College, Chennai – 602 105, Tamil Nadu, India
[2]Department of Biomedical Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India
✉ johnpaulv2490@gmail.com

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Abstract: Due to anthropogenic activities the Noyyal River, a lifeline for Coimbatore and Tirupur district's water resources in Tamil Nadu, India, is facing severe degradation. Combined rapid industrialisation and urbanisation have put immense pressure on modern civilisations increasing water demand on fresh water bodies. The major contributor to Noyyal River pollution is the textile industries in and around Tirupur. This study aims to identify the primary pollutant of the river water and propose potential remediation strategies. The water quality of the river is evaluated through extensive sampling across various locations of the river stretch and parameters including pH, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and heavy metals are analysed. The results exceeding permissible limits set by regulatory agencies indicate the formidable level of pollutants. The primary contaminants affecting the river's ecosystem and public health are textile dyes, heavy metals and organic compounds. Aquatic biodiversity is declining due to the degradation of water quality and it adversely affects the livelihoods of communities dependent on the river and also poses significant risks to human health through direct contact and consumption of contaminated water. Employing MATLAB, the study engages parametric analyses to predict past, current, and future trends in water quality parameters including pH, BOD, COD, TDS, hardness, lead, zinc, manganese, cadmium, chlorine, and microbial indicators.

Key words: Chemical toxicants, dye, harmful chemicals, textile industry, wastewater, water quality.

Introduction

The ecological integrity of the Noyyal River has been severely compromised by industrial pollution in particular, by the discharges from the textile industry. The heavy metals and dyes from the textile effluents deplete dissolved oxygen levels and proliferation of harmful microorganisms by exerting a substantial oxygen demand on the river. Pollutants such as surfactants, sizing agents and halogenated organics pose significant risks to human health through direct contact and consumption of contaminated water by disrupting aquatic ecosystems. The dyes used in textile industries to produce vibrant colours added to clothes have high salt content and persistent nature that contributes significantly to water pollution. As a result, the Noyyal River faces a critical challenge, in deteriorating water quality and the loss of biodiversity. In order to address this social issue a detailed assessment of the river's water quality is vitally important.

Study Area

Originating from the Western Ghats and flowing into the Cauvery River, the Noyyal River is a notable water body in the Tamil Nadu state of southeast India. The

*Corresponding Author

river stretch is 180 km long and 25 km wide and covers a wide area of 3500 sq. km. To indicate a predominantly agrarian economy this basin covers 1800 sq. km of agricultural land. In terms of population density rural areas hold around 120 individuals per square kilometre, while urban areas accommodate a much denser population of 1,000 people per square kilometre.

Literature Review

Venkatesan et al. (2024) studied the ecological crisis that arose in the Noyyal River due to improper waste management. This study could be relevant to reducing the environmental strain of Noyyal by offering sustainable construction materials derived from waste, potentially diverting harmful waste from the river system.

Udayakumar et al. (2011) examined the effects of textile dyeing and bleaching effluents on the surface water quality of the River Royal in Tiruppur district, Tamil Nadu, India.

Govindaraj et al. (2022) **s**tudy focussed on identifying non-carcinogenic risk zones using geospatial techniques from groundwater contamination in industrial areas. It offers a valuable perspective on the contamination issues that affect the Noyyal River, particularly from industrial discharges.

Shenkani and Jeyanthi Jeeva (2015) collected water samples from three borewells and three open wells in Kanyakumari district, noting that electrical conductivity, alkalinity, total hardness, iron, and fluoride levels did not meet WHO guidelines for potable water.

Venkatesan et al. (2024) studied sustainable energy generation along river systems like the Noyyal by hydro-power plants that provide insights into potentially supporting sustainable energy needs while promoting the health of the river ecosystem, as long as the environmental impacts are carefully managed (Venkatesan et al., 2023).

Sugirtha & Sheela (2015) assessed seasonal variations in water quality in the Manakudy estuary on the Southwest coast of India, finding significant differences in cations (Ca, Mg, Cu, Li) between stations, and in nitrogen levels between stations but not between months.

Govindaraj et al. (2024) paper, deals with water treatment methods by using natural materials like *Chrysopogon zizanioides* and *Hemidesmus indicus*, which could provide ecologically friendly ways to treat polluted waters, potentially benefit efforts to restore the Noyyal and also directly applicable addressing the pollution in the Noyyal River.

Venkatesan et al. (2024) assessed the ecological state of the Noyyal River through Satellite images processed with machine learning could help track pollution sources, assess land use changes, and provide real-time monitoring of river health.

Tallapragada et al. (2024) deal with agricultural technology, particularly rice prediction using AI. Its link to the Noyyal River could involve agricultural runoff, which is a significant ecological challenge for the river. AI could also be explored for monitoring agricultural practices along the river basin, ensuring more sustainable practices and reducing pollutants.

Mahalakshmi et al. (2014) conducted a study on the River Royal, focussing on the challenges faced in the Tiruppur area due to high concentrations of industrial waste from the textile dyeing industry.

Methodology

This process starts with a complete examination of existing research and the establishment of a conceptual framework to guide the investigation. The research is subdivided into two primary areas: water quality assessment and wastewater treatment. For assessing the water quality surface water samples were collected from the Noyyal River and subjected to analysis for physical, chemical, and heavy metal parameters. The primary pollution source refers to the dye factory The collection of necessary materials and the selection of a basic reverse osmosis (RO) plant for filtration is determined for the segmentation of wastewater treatment. Interpretation of data collected, detailed discussion of the results and formulating the overall conclusion of both water quality assessment and treatment process is the final stage of this study.

Sample Collection and Analysis

In the past it was discovered that the Samalapuram region along the Noyyal River has been severely overexploited, leading to significant ecological degradation. This has raised concerns regarding the long-term impacts on both aquatic biodiversity and the local communities dependent on the river stretch was found to be over-exploited. So, Samalapuram was chosen as the collection point. The samples were collected along the 40 km river stretch, with sampling distances varying between 3 km to 4 km to ensure comprehensive coverage of the affected areas. Both rainy and non-rainy seasons were chosen to assess seasonal variations in water quality. T 20 sets of

samples were collected in 10 locations designated as S_1 to S_{10}, which gives the total number of 60 samples. Furthermore, the domestic users started to rely on water from other basins in particular from the Bhavani basin in the north masked the immediate solution. This was mainly because of the lack of awareness among the local residents. Furthermore, the reliance of many domestic users on water imports from other basins, particularly from the Bhavani basin in the north, has masked the immediate water constraints faced by the region. This reliance on external sources may have led to a lack of awareness among local residents regarding the true extent of water pollution and scarcity issues within the Noyyal River basin. The time interval maintained for the collection of samples is Morning to Evening. Locations include Samalapuram (S_1), Pallapalayam (S_2), Aiiyagikovil (S_3), Mangalam (S_4), Kozhi pannai (S_5), Andipalayam (S_6), Rayapuram Bridge (S_7), Tiruppur ICC (S_8), Kasipalayam (S_9) and Unjakaatuvalasu(S_{10}). As shown in Figure 1, the chosen locations were marked in the toposheet by using GIS which facilitates a better understanding of the geographical context and aids in identifying potential sources of pollution to provide a comprehensive understanding of the current water quality situation, physical, chemical, and heavy metal properties of the river water have been assessed and compared to standard wastewater values. Graphical representations, generated using MATLAB, depict these comparisons, offering insights into the extent of deviation from standard norms and highlighting areas of concern regarding the Noyyal River's water quality.

Water Quality Index

The water quality index (WQI) is an exhaustive indicator that is used to analyse the overall qualities of water samples including their physical, chemical and biological parameters in a single value. WQI helps us to differentiate the suitability of water for recreation, agriculture, drinking and industrial use. In this study region water quality has significant issues mainly because of the industrial effluents from dyeing units and untreated sewage being discharged into the river. However, because of the strict norms imposed by the government on effluents being discharged into the river and the treatment process being carried out the various parameters of water are within the permissible limits as shown in Table 1.

Lead

Lead, a toxic heavy metal has a permissible limit of 0.01mg/L but when found in excess in drinking water can cause neurological damage, especially in humans.

Figure 1: Sample collection, sampling points and samples collected.

Table 1: Parameter analysis

Location parameters	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*	*S9*	*S10*
Pb (mg/L)	6.6	6.9	6.6	9.5	8.6	6.8	6.3	6.2	5.6	5.5
Cd(mg/L)	6.1	5.7	6.1	5.8	6.7	8.4	4.7	8.1	4.4	8.4
Zn(mg/L)	5.9	5.6	5.9	8	5.9	5.9	6	8.6	6	5.9
Cr(mg/L)	7.8	7.4	7.8	8	9.1	9.1	5.9	7.1	6.4	7.8
F(mg/L)	7.6	7.3	7.6	10.1	7.3	7.8	7.6	7.6	7.8	7.6
TDS(mg/L)	1075	1101	1075	870	1093	1146.7	1170.7	1093	1103.7	1095
Mn(mg/L)	0.6	0.6	0.6	0.8	0.8	0.6	0.7	0.5	0.6	0.6
Hardness(mg/L)	555.4	584.7	555	441.4	708.7	552	588.7	555.4	562.1	568.7
So2(mg/L)	448.5	438.9	488.5	282.9	688.5	488.5	488.5	688.5	488.5	488.5
S2-(mg/L)	0.5	0.4	0.5	0.9	0.6	0.8	0.5	0.5	0.5	0.5
Cl(mg/L)	513.4	539.8	513.4	780	580	680.1	513.4	475.1	483	553.4
pH	6.5	6.1	6.1	6.2	6.2	6.2	6.4	6.2	6.4	6.5
BOD(mg/L)	16.3	16.5	16.3	16.4	17.8	18.8	16.3	16.5	18.6	16.3
COD(mg/L)	12.7	13.1	12.7	17.2	15.8	13.4	13.7	13.3	15.6	15
Cl	18.3	24.8	18.3	19.4	19.4	18.6	18.3	19.3	19.7	19.8
Non rainy season										
Pb (mg/L)	7.2	6.9	9.5	6.9	7.1	7	6.5	6.8	7.7	8
Cd(mg/L)	7	5.7	5.7	5	9.4	4.7	6	5.6	7	7
Zn(mg/L)	9.9	4	7	5.9	5.9	5.6	5.94	6.6	5.94	5.5
Cr(mg/L)	12	9.5	7.3	7.7	7.6	8.4	7.7	7.7	8.94	8.3
F(mg/L)	5.3	8	9.10	7.6	7.2	7.5	7.6	7.6	7.2	7.4
TDS(mg/L)	1076	1101	1041.3	1085	1098.2	1121	1075	1134	1121.3	1142.6
Mn (mg/L)	13.8	0.6	0.7	0.58	0.6	0.65	0.6	0.61	0.84	0.853
Hardness(mg/L)	477	584.7	537.4	558.7	555.3	559.3	555.39	575.3	518.5	525.39
SO_2 (mg/L)	354	439	412.8	488.5	488.5	471.3	488.5	501.5	488.3	487.18
S2-(mg/L)	0.44	0.4	0.8	0.47	0.47	0.54	0.47	0.47	0.47	0.54
Cl(mg/L)	971.3	540	690.1	513.7	513.4	484.1	513.4	513.4	513.4	480
pH	6.1	6.2	6.2	6.4	6.4	6.7	6.0	6.5	6.5	6.5
BOD(mg/L)	15	17.7	17	16.3	16.6	16.7	16.3	17.8	17.1	17.1
COD(mg/L)	13.3	13	13.6	13.5	13.3	13.8	12.6	13.8	13.7	13.8
Cl	38	45	20	18.3	19.8	19.6	18.3	19.3	19.5	19.1

Noyyal River in Tiruppur region is considered, the presence of lead is high up to 9.5 mg/L, it is mainly due to the industrial activities in Tiruppur particularly those related to the textile industry and bleaching process.

Cadmium

The presence of Cadmium in water is a threat to water quality, particularly in the Noyyal River in Tiruppur, as evidenced by Water Quality Index (WQI) assessments. Cadmium is a highly toxic heavy metal, which causes severe health problems such as kidney damage, bone demineralisation, and cancer upon prolonged exposure. The presence of cadmium is mainly due to the use of dyes that contain cadmium-based pigments which results in river water getting polluted.

Zinc

Zinc contamination is another important concern affecting the water quality of the Noyyal River in Tiruppur, as demonstrated by the Water Quality Index (WQI) evaluation. Although Zinc is an important trace element for living organisms, it becomes toxic at elevated concentrations, leading to adverse effects on aquatic life and human health, such as gastrointestinal distress and interference with the absorption of other essential minerals.

Fluoride

Fluoride is naturally present in water and is beneficial at low concentrations and causes dental fluorosis and skelton fluorosis is caused at excessive levels. The permissible limit is 1.5 mg/L the concentration of fluoride is 10.1mg/L.

Total Dissolved Solids (TDS)

TDS indicates the combined concentration of minerals, salts and organic matter. High concentration of TDS indicates that water quality is poor making it not suitable for drinking and irrigation purposes. Textile processing units and chemical industries contribute much to the TDS load in the river.

Results and Discussion

MATLAB Analysis of Past Year Noyyal Water Quality Parameters

In 2016, the Noyyal River faced severe pollution primarily due to the discharge of waste from dye factories and textile industries. However, it lacks a thorough discussion of the long-term ecological impacts on both aquatic biodiversity and local communities dependent on the river. The dumping of garbage used fabrics, and dyes from approximately 700 manufacturers further exacerbated the pollution levels, resulting in significant environmental concerns. This pollution has impacted various aspects of the river's ecosystem, leading to serious problems across multiple fronts. Furthermore, the reliance of many domestic users on water imports from other basins, particularly from the Bhavani basin in the north, has masked the immediate water constraints faced by the region. Additionally, the analysis of water quality parameters is broad, lacking focus on the specific sources and mechanisms of pollution, especially from textile industries. This reliance on external sources may have led to a lack of awareness among local residents regarding the true extent of water pollution and scarcity issues within the Noyyal River basin. Moreover, strengthening the linkage between data findings and practical policy recommendations would enhance the paper's contribution to water quality management initiatives. To provide a comprehensive understanding of the current water quality situation, physical, chemical, and heavy metal properties of the river water have been assessed and compared to standard wastewater values. Graphical representations, generated using MATLAB, depict these comparisons, offering insights into the extent of deviation from standard norms and highlighting areas of concern regarding the Noyyal River's water quality. Figure 2 depicts the analysis of past values of water quality parameters using MATLAB. Furthermore, the reliance of many domestic users on water imports from other basins, particularly from the Bhavani basin in the north, has masked the immediate water constraints faced by the region. This reliance on external sources may have led to a lack of awareness among local residents regarding the true extent of water pollution and scarcity issues within the Noyyal River basin The enforcement of regulations requiring dye units to implement zero liquid discharge systems for treating waste has likely played a significant role in reducing pollution levels.

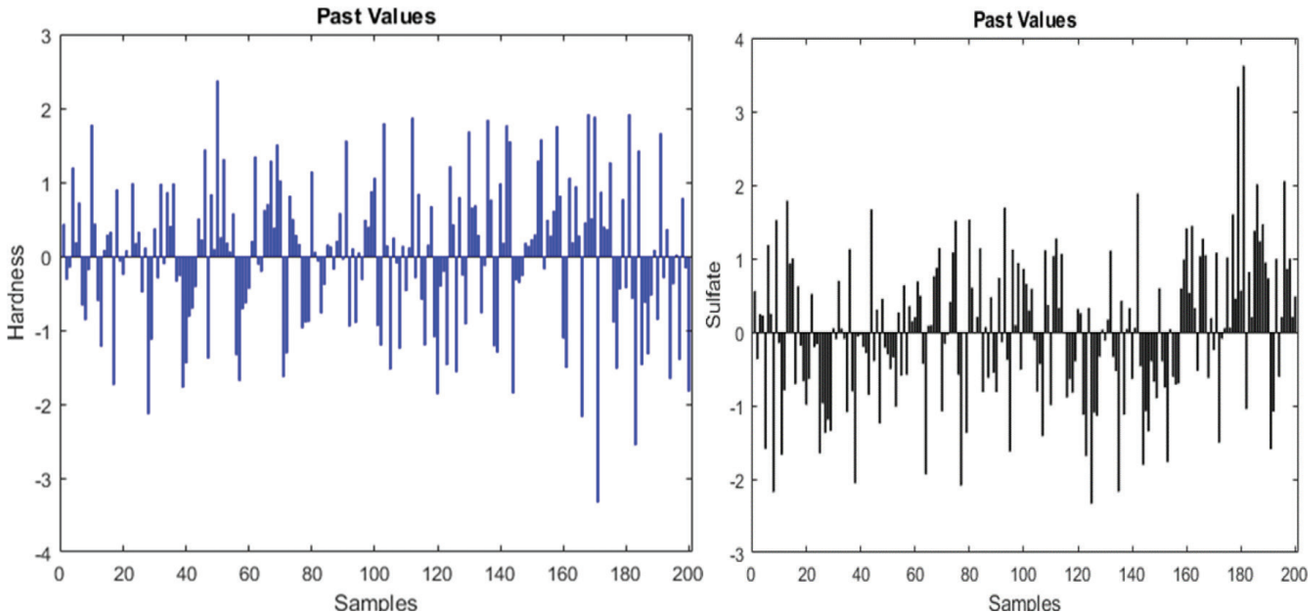

Figure 2: Analysis of past values of water quality parameters using MATLAB.

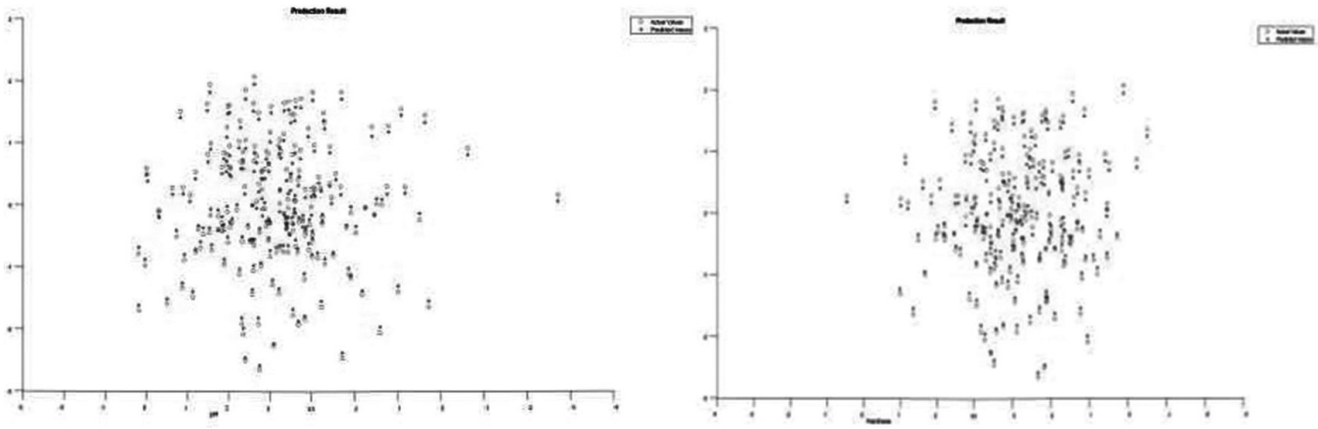

Figure 3: Interpolation of past, present and future water quality on Noyyal River using MATLAB.

MATLAB Analysis of Future Year Noyyal Water Quality Parameters

In this study, the analysis of water quality in the Noyyal River basin is done using MATLAB software to map the water quality parameters for the past, present and future. To show the increment and decrement of the toxicity of the water sample this was collected and past year's water quality. We analysed the future year water quality of Noyyal River through past and present years of data in Figure 3.

Conclusion

In this experiment, the focus was on evaluating the water quality of the river's effluent. Fifteen segments of the river were meticulously examined, and their water quality characteristics were analysed. Throughout the data analysis process, it was observed that the water quality of these fifteen segments exhibited variations from year to year. The findings of this study hold immense significance as they provide valuable insights for formulating policies and implementing solutions aimed at improving the water quality of the Noyyal River to meet appropriate standards. By comprehensively analyzing the water quality data across different segments of the river, researchers can identify trends, patterns, and areas of concern, thus informing targeted interventions for enhancing water quality management practices. Moreover, the study highlighted the potential of MATLAB as a promising tool for comparing the river's water quality against model input parameters to assess its overall quality.

Conflicts of Interest

The authors assert that there are no conflicts of interest.

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