RESEARCH ARTICLE

DOI: 10.34256/ijceae2515

International Journal of Civil, Environmental and Agricultural Engineering

Identification and Risk Analysis of Pollutants Present in Water Resources of Coimbatore (Noyyal River), India

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Received: 30-01-2025, Revised: 24-04-2025, Accepted: 29-04-2025, Published: 07-05-2025

Abstract: This study was carried out to assess the physico-chemical characteristics and evaluate the heavy metals chromium (Cr), Cadmium (Cd), Nickel (Ni), Lead (Pb), Zinc (Zn) and Copper (Cu) pollution in the Noyyal river, Coimbatore, India. River water samples were collected during November 2019 and analyzed in the laboratory. The parameters including pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), turbidity (TURB), total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), chloride, nitrate, fluoride, sodium and potassium were analyzed for the collected samples. The water quality index is calculated, to assess the quality of river water. The results obtained highlighted that Noyyal River was highly polluted due to domestic sewage, municipal wastes and industrial effluents. These findings suggest that the river water needs treatment before consumption.

Keywords: Physico-chemical characteristics, Noyyal River, Heavy metals, Environment risk, Pollution Assessment

1. Introduction

Water is a vital entity for life and essential for all related activities of agricultural and industrial process and survival of all living creatures' lives. Maintenance of water resources is essential for future growth (Jia et al., 2019) [1]. Pollutants in the water adversely affect the quality of water thereby affecting the health of in taking ones (Wu et al., 2020) [2]. The surrounding environment is one of the main contributors of contaminants affecting the water quality. Agricultural production, domestic sewage and industrial effluent discharge contaminates the water (Kim *et al.,* 2019) [3].

Rapid industrialization and increased population growth lead to deterioration of water quality. Today preservation of water resources remains a challenge to humankind (Abbasnia *et*

al., 2019) [4]. Industrialization is contaminating water resources (Qian *et al.,* 2020) [5]. In India more amount of water resources is available. Increased population over recent decades resulted in the consumption of a larger quantity of water. Also, it loads more pollutants into the water resources. Nowadays water shortage is one of the major issues being faced by mankind. Therefore, researchers should give more attention to water resources. They should search for solutions to the problems associated with water resources.

Burgeoning industrialization and ever-growing population depleting ground water resources. They are responsible for discharge of municipal, domestic and industrial waste. Municipal waste contains an enormous number of organic compounds. Discharge of kitchen waste is one of the major contaminants of water bodies. India generates about 30 million tons of domestic waste. These domestic wastes possess high alkalinity and contain an adequate amount of organic, phosphorous, dissolved oxygen and nitrogen compounds. These wastes are discharged into nearby water bodies. Presence of these particulate matter adversely the health of the environment. It is projected that approximately 50% of the global population will encounter water scarcity by 2025, and 75% of the population will experience issues related to freshwater availability by 2050. Therefore, the utmost care should be given to the monitoring and evaluation of water systems.

Heavy metal pollution, another environmental component, is gaining serious attention in river water pollution. Heavy metals are toxic, persistent, and difficult to degrade and could easily enter the intake through the food chain. It has been reported that tons of heavy metals were discharged into rivers every year. These heavy metals from the surface water accumulate in the aquatic species. As the concentration of heavy metals exceed the tolerance limits, they tend to cause harmful effects to the aquatic living organisms (Li et al., 2020) [6]. These heavy metals also cause a severe threat to human beings by entering the human body through food chain. They produce carcinogenic and teratogenic effects. Thus, special attention is necessary to health risks concerned with heavy metals.

The Noyyal River is highly polluted with heavy metals and domestic wastes due to human activities and industrial wastes. Release of organic and inorganic pollutants through agricultural waste, industrial waste, municipal solid waste and domestic sewage waste is increasing dramatically due to increased population and industrial growth (Srinivasan et al., 2016) [7]. Therefore, the concentration of heavy metals increases. Noyyal River flow through cities of Coimbatore. The city of Coimbatore is famous for its textile industrial world where huge quantities of small and large-scale industries are located. These industries discharge several organic and inorganic chemicals into the river (Selvarani et al., 2016) [8]. Today, Banks of Noyyal River are considered as industrial wastelands. Many studies have been carried out regarding the pollution of Noyyal River. Karunanidhi et al., (2022) [9] evaluated the heavy metal pollution in the Noyyal River and determined the level of contamination of heavy metal. Gayathri et al., (2020) [10] analyzed the pollution of Chinnar and Noyyal River and found that Noyyal River is

highly polluted with heavy metals rather than Chinnar due to industrial waste discharges. Manikandan et al., (2016) [11] investigated the physicochemical and heavy metals parameters in lakes of Coimbatore. Mohanraj et al., 2020 [12] carried out research about pollution status of wetlands of Coimbatore [13].

Realizing the necessity in recovering the deteriorated Noyyal River, this study aims to (i) analyze the physicochemical parameters and heavy metal parameters in Noyyal River (ii) determine the level of contamination by pollution indices Babunath 2017 [14].

2. Material and Methods

2.1 Study area

Coimbatore, commonly refereed as Manchester of South India, is one of the highly industrialized cities in south India and is famous for Textile factories. The city is bound by mountain range from Western Ghats from North, West and the south and slopes eastward. Noyyal River, a tributary of Cauvery runs through Coimbatore and forms southern boundary to city. The Noyyal River arises from the Vellingiri hills in the Western Ghats. The river basin is 180 km long and 25 km wide. It covers a total area of 3,500 km^2. The area receives only less rainfall. Noyyal River tank system is the water resource for the entire area. Noyyal River holds up water from rainfall during monsoon season. The industrial activities such as leather tanning, textile, vegetable oil and rubber in and around city disposes the waste into Noyyal River. The increases population of the city is another reason for contamination of Noyyal River. Therefore, Noyyal River acts as a carrier for pollution. In most of the season, as water remains stagnant, contaminants enter groundwater thereby polluting the ground water also.

2.2 Sampling station

Three sample stations, namely S1- Perur town panchayat, starting place for the pollution in the Noyyal River. It covers an area of about 6.4 km^2 on the banks of river Noyyal, 22 km from the place of its origin in the Vellingiri Hills.S1 was the starting place for pollution.

S2-Athupalam area. It is near to Ukkadam. This area is a highly populated area.

S3-Singanallur area. It is a highly populated industrialized zone with agricultural activities. Proper drainage is not provided in this zone and thereby sewage gets direct disposal into the river water. Figure 1 displays the photograph of sampling station.

2.3 Sample Collection

Samples were collected from three different stations. About 5 L of water samples were gathered in polyethylene bottle and preserved under the temperature of 4^{0}C.

Figure 1. Photographs of study area

The collected samples were subjected to hydro chemical parameter analysis. Potassium (K^+) and Sodium (Na^+) were analyzed using a flame photometer. Nitrate (NO_3) were examined using UV-single-beam spectrophotometer (SYSTRONICS, Japan). The physiochemical parameters were analyzed by titration method prescribed in the American Public Health Association (APHA, 2012).

2.4 Heavy metal pollution index

Heavy metal pollution index (HPI) represents the combined influence of individual heavy metals on the overall quality of water (Sheykhi and Moore, 2012) [15]. It was calculated using the following equation:

$$HPI = \frac{\sum_{i=1}^{n} W_I Q_I}{\sum_{i=1}^{n} W_I} \quad (1)$$

$$W_I = \frac{K}{S_i} \quad (2)$$

$$Q_i = \sum_{i=1}^{i=n} \frac{V_i - I_i}{S_i - I_I} \quad (3)$$

Q_i is the sub-index, V_i is the monitored value, I_i is the required value and S_i is the standard value. Normally HPI value of 100 implies critical risk and HPI value higher than 100 indicates sever risk to human health.

3. Results and Discussion

3.1 Physico-chemical characteristics of water samples

The physicochemical parameters including pH, Temp, EC, DO, TURB, TDS, BOD and COD are presented in Table 1. Huge deviation is found in the concentration of various contaminants in the river. Discharge of industrial effluents, domestic sewage and discarding of municipal wastes are affecting the water quality. The pH of river water in different stations was found to be moderately alkaline and was within the permissible limit of drinking water in station 1 and station 2 respectively. The pH variance from 9.2 to 9.8 in station 3 indicates the increase in alkalinity due to pollution (Sankind and patil., 2004) [16]. The temperature was also similar in three stations and there was not much difference. Slight variation in temperature in station 3 was due to thermal change in surface water caused due to the release of domestic and sewage wastes directly into the river. EC of water is a direct measure of total dissolved salts. Higher level of EC in station 1 indicates high salt concentration in the river. This may be attributed due to the presence of sodium chloride or sodium sulphate used in fixing dyes on fabric in textile industries. This points out the discharge of industrial effluents into the Noyyal River. Dissolved oxygen is an important parameter in water quality determination. Presence of oxygen demanding materials in the form of organic and inorganic in the river grounds reduction of DO in the water. The level of DO below a critical value causes a severe threat to aquatic environment. DO less than 3 mg/L causes risk to human health. It was observed that DO of water was maximum at station 3 and less value at other stations.

Table 1. Physico-chemical parameters of water samples in different stations of Noyyyal River

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
pH	7.8	7.4	7.7	7.9	8.1	7.4	9.4	9.2	9.8
Temperature	26	26.2	26.5	26.8	27.4	26.8	27.2	27.5	28.4
EC	4450	3420	2541	600.25	548.54	478.56	800.54	600.56	703.26
DO	2.95	4.65	3.68	3.5	3.74	3.35	4.12	4.56	4.78
TURB	9.2	7.6	6.5	10.21	9.87	11.52	12.25	13.56	15.52
TDS	228.5	342.56	455.23	2100.32	3200.47	2847.24	2500	2250	3000.52
BOD	15.53	9.47	12.36	5.25	6.74	7.48	6.87	7.25	7.95
COD	20.28	16.58	18.47	9.12	10.21	11.48	10.58	10.52	10.32
Chloride	195.6	94.2	85.2	350.64	400.14	321.89	1210	995	1180
Nitrate	200	188.4	176.2	65.21	74.56	68.49	280.45	302.87	310.25
Fluoride	0.96	0.71	0.65	1.24	0.96	1.74	1.54	1.84	1.96
Sodium	38.26	58.62	64.58	100.54	96.52	88.42	152.23	162.58	174.89
Potassium	10.52	8.54	7.56	8.78	7.56	9.45	9.52	10.48	10.96

This is due to the discharge of industrial effluent containing oxidizable organic matter. The variation in DO in three stations might be due to temperature changes and anthropogenic activities involved.

High TDS and chloride levels are found to be high at athupalam (station 2) may be due to the adjoining of textile dyeing and bleaching units. Dumping of suspended solid wastes from dyeing and textile industries tends to increase the amount of TDS (Rahman et al., 2013) [17]. Effluents of dyeing units contain low molecular organic compound and dissolution of these compounds is responsible for higher TDS value (Manikandan et al., 2016) [11]. The level of Calcium, magnesium and sulphate is found to be higher. This may be due to discharge of industrial effluents or re-suspension of old sediments.

Higher levels of BOD show that the affected area suffers from domestic pollution. BOD was found to be low at stations at 2 and remains high at other stations. This may be due to the mixing of sewage and discharge of organic waste from dyeing units. A higher value of COD was noticed at station 3 which may be due to the discharge of industrial waste containing high level of organic matter.

3.2 Sources of metals in Noyyal River

At the site, presence of heavy metals –nickel, zinc, copper, chromium, cadmium and lead clearly depicts the industrial pollution. The concentration of cadmium, lead and nickel exceed drinking water standard. The calculated values of the heavy metals are presented in Table 2. The maximum concentration of Cr was 1.54 mg/L at station III. The concentration was high due to the direct discharge from the industries. The major sources of Cr are from the effluence of tannery industries. Pb concentration was found to be below the permissible limit, and it found to be maximum at station 2 showing that river water is highly polluted by this metal due to the discarding of domestic and agricultural wastes to the river basin.

Table 2. Sources of Heavy metals in different places

Parameters	Station 1	Station 2	Station 3
Cr	0.175	0.186	0.172
Cd	0.024	0.035	0.042
Ni	0.084	0.076	0.094
Pb	0.152	0.174	0.185
Zn	1.825	1.548	1.645
Cu	0.14	0.215	0.152

Higher concentration of Ni was found at station 2 and suggests that effluents from various small-scale industries are mixed at this point. The major sources of nickel are electroplating, dyeing, steel refractory and municipal solid waste. The zinc concentration was in the order: station 2 > station 3 > station 1. Station 2 fall under the category of higher risk. Steel and silver-plating industries are the major sources of Zinc pollutant.

The concentration of Cu is found to maximum at higher at station 2 and station 3. They fall under the category of high risk. High contamination at station 2 is due to the discharge of sewage sludge whereas at station 3 due to the discharge of many dye and textile effluents. Among all stations Cd is found to be high at station 3 denoting the area is highly contaminated with effluents of various industries. However, water from the stations considered are not utilized for drinking purposes. It might be used for agricultural activities. But usage of this contaminated water for irrigation purpose might tend to lead to accumalation of heavy metals in ground water, soil and plants (Barmen et al., 1999) [18]. Moreover, the quality of ground water of Coimbatore is also being depleted due to contamination of heavy metals and becomes unsuitable for drinking purposes.

The physico-chemical and heavy metals parameters from different stations were found to be higher in concentration. Observation indicates that Noyyal River is being turned into bearer of industrial effluent and wastes.

3.3 Correlation among heavy metals in Noyyal River water

Cd, Ni, Pb, Zn and Cu shows positive correlation with Cr. It indicates that sources of heavy metal pollution are of similar sources of anthropogenic activities (Cengiz et al., 2017) [19]. Table 3 represents a strong positive correlation among heavy metals of Cd and Pb (0.926), Ni and Zn (0.883). Industrial effluent discharge and agricultural wastes account for increased concentrations.

Table 3. Correlation coefficient of heavy metals

	Cr	Cd	Ni	Pb	Zn	Cu
Cr	1					
Cd	0.823	1				
Ni	0.155	0.019	1			
Pb	0.927	0.926	0.181	1		
Zn	0.105	0.113	0.883	0.153	1	
Cu	0.374	0.110	0.637	0.361	0.361	1

3.4 Heavy metal pollution index (HPI)

Concentration of heavy metals in river metals is determined by Heavy metal pollution index (HPI). HPI values obtained in three sample station ranges in the value of 50 to 250 indicating that concentration of metals in water causes low to high health risks. HPI values were greater than 100 in station 2 and 3 respectively. Comparatively, concentration of Cr, Cd, Ni, Pb and Cu was higher than permissible limits. The concentration of Zn was less than permissible limits in the samples. The concentration of metals was in the order station 3 > station 2 > station 1. These observations indicate that higher concentration of metals in this area causes hazard to the ecological system.

4. Conclusion

The results of this research indicated that quality of Noyyal River water is naturally deteriorated. The data analysis delivers that sewage, municipal wastes, industrial and agricultural wastes were the major sources of pollutants in the Noyyal River. Station 2 and station 3 were severely contaminated by heavy metals such as Cr, Cd, Ni and Cu. Comparison of water quality parameters with the WHO and BIS standards suggested that samples are not fit for drinking purposes. The analysis made in the study area showed that there is a need for pollution control. Awareness regarding heavy metals and their risk should be created among the public. For good health and better well-being, intake of treated water is mandatory. Zero waste strategy should be implemented in industrial sectors to reduce pollution in rivers. The status of water quality should be checked periodically. Pollution sources should be identified. Encroachments should be removed in and around the river. Solid waste and debris should be removed.

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Funding: No funding was received for conducting this study.

Conflict of interest: The Author's have no conflicts of interest to declare that they are relevant to the content of this article.