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Assessment of the Seasonal Water Quality Changes in Semi-Urban Surface Tanks of Noyyal River Basin

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The history of Noyyal river in Coimbatore is known for water quality and taste since the colonial period. The river water is used mainly for drinking, irrigation and industrial purposes to districts of Coimbatore, Tiruppur and Karur with many anaicuts and tanks. In the recent past due to urbanization and industrialization the river water has been polluted in the greater extend.
Place and Duration of Study: The study was conducted to investigate the water quality status of five important upper reach semi-urban tanks of Noyyal river basin in the year 2020 -2021.
Methodology: We have collected the sample season wise in the five tanks and analyzed for pH, EC, TDS, TSS, total hardness, alkalinity, chlorides and sulphates as well as heavy metals such as zinc, copper, cadmium and lead.
Results: The results of our water quality analysis showed that most of the parameters are above the maximum permissible limits of CPCB standards for drinking water in India. The heavy metals concentrations were many folds higher than the CPCB permissible limits. The correlation analysis,

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Anova and PCA showed that the EC and TDS, alkalinity and sulphates, chlorides and sulphates and alkalinity and chlorides had higher correlation in the water quality analysis and they are interrelated to one another. In the monsoon season the pollution status is less and during summer season the pollution load is higher in the all tanks. During the monsoon season because of intensive water flow dilute the pollution load as well high rate of degradation due to high dissolved oxygen content of river water. Since, he Noyyal river is seasonal river, during summer, there would be very less or no flow of water into the tank increase the pollution load. The Narasampathy tank had comparatively less pollution than other tanks, since, it is the first tank in the upper reach of the Noyyal basin and has less inhabitants and industry.

Conclusion: We concluded that the tanks are polluted due to urbanization and industrialization in and around the Noyyal basin and there is an urgent need to tackle this problem by making eco-friendly and economically viable treatment system to sustain the water quality.

Keywords: Water quality analysis; surface water pollution; tank network system; physico-chemical analysis.

1. INTRODUCTION

Water, an essential resource, and is the major element of all living structures on the earth. Water plays an important role in human life. It is necessary for industry, agriculture and human existence [1]. Water is available in two major places such as surface and ground in the earth. By gravity, surface water percolates and infiltrates into subsurface that eventually reaches the aquifers. Surface water bodies are heavily exposed to pollution due to the waste disposal [2]. Surface tanks were developed to accommodate the spatial concentration of the rainfall during the monsoon and to use it throughout the off season of rainfall and ground water is being used, whenever the surface water is limited. Due to the urbanization and industrialization, negative significances can be visualized in the natural resources and the surrounding environment. The pollution is especially more in the urban settlements which are due to the higher population and insanitary practices. Water quality data emphasizes the interpretation of a water analysis with applications on ground water as well as surface water pollution and the contaminant transport. Surface water investigation can have a definite pathway for the groundwater quality and environmental studies on the aspect of pollution as well as the environment is concerned. Groundwater quality assessment deals with the pollution status of the surface water bodies. It is essential to numerically model the groundwater quality and thus makes us to plan the future needs to overcome the severe water quality crisis. According to the 11th five Year plan in 2007 to 2012, there was about 2.17 lakh quality affected habitations in the country with half were affected with surplus iron, trailed by fluoride, salinity, nitrate and arsenic, which is one of the major reasons of several diseases due to the unclean water supply and poor sanitation. The various chemical reagents used in textile industries contributes to severe water pollution [3].

Since, Tamil Nadu is being a monsoon dependent state, the quantity and quality both surface and groundwater are totally depending on the rainfall. Most of the rivers in Tamil Nadu have been polluted due to the urban settlements with industries and by the release of untreated waste water into the surface water. Urbanization and increasing socioeconomic activities have degraded natural resources globally [4]. The annual waste water generation of Tamil Nadu is about 6421 MLD within which only 1492 MLD waste water is treated, which is just 25% of the total waste water generation [5] and thus necessitates us to monitor the water quality continuously in both surface and groundwater. Coimbatore a well-planned city with a vast tank system network. These surface tanks are inter connected with one another and they also play an important role in the recharge of the groundwater in the Coimbatore region. Noyyal River, which originates from Vellingiri hills in Coimbatore flows through four districts – Coimbatore, Tiruppur, Erode and Karur and also it is the source for the surface water tanks in the Coimbatore district, is now turning into the drainage tanks due to the urbanization and industrialization of the city [6]. Hence, there is need to assess the quality status of surface water tanks and as well as ground water. Keeping this view, in this paper we are going to discuss the five tanks, which are situated in the upper reach Noyyal river basin.

2. MATERIALS AND METHODS

The water samples were collected from the five major tanks in the study area. In Coimbatore district most of the domestic waste water is released into the surface water tanks which severely affect the surrounding and the groundwater quality through seepage. The sampling was collected by grab sampling method by following the sampling protocols.

The three samples were collected for all the 5 tanks during summer, winter and monsoon seasons in the year 2020 -2021 and to observe the change in the quality of water at different timings based on the wastewater generation and wastewater flow into the tanks in the study area as well as the time of high concentration from the remote point to the sampling point. The seasons are well defined through basin and the rainfall management has balance in its distribution [7]. The samples were sealed and transferred to the laboratory and the analysis were carried out by using standard APHA procedures [8]. The following chemical parameters were analysed in the laboratory using standard procedures they are pH, Electrical Conductivity, Alkalinity, TDS, TSS, Sulphates, Chlorides, Total Hardness and Heavy Metals. The sampling points are located by using GIS maps in the Fig 1.

The results of the water quality analysis were statistically analyzed using the SPSS software and its results are discussed below on the basis of tanks in different seasons. The correlative analysis was performed to have an idea about the correlation between the various water quality parameters analyzed in this study.

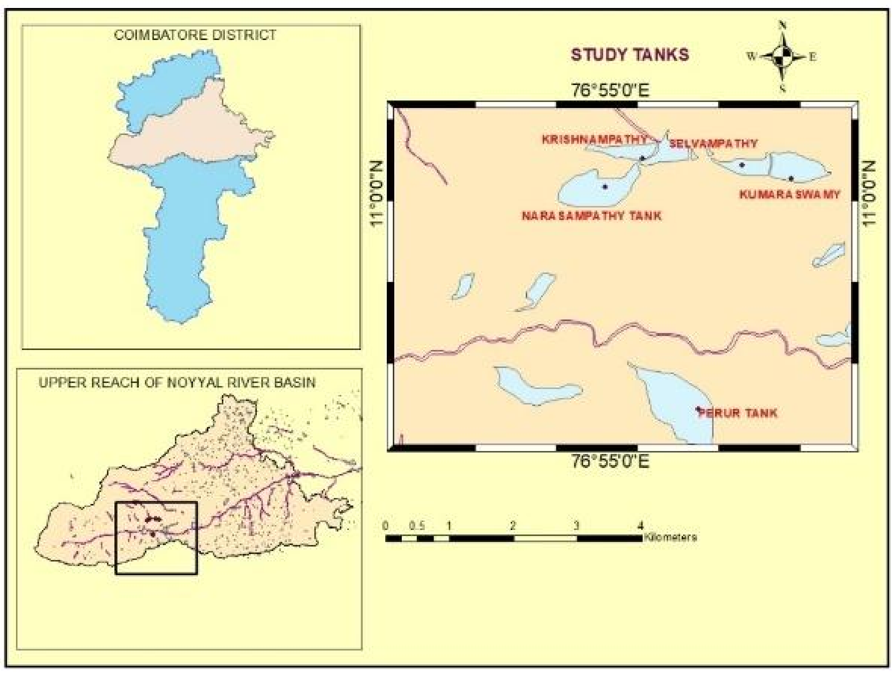

Fig. 1. Study area map

2.1 Standards for Drinking Water (CPCB standards)

Table 1. Standards for drinking water

Total Alkalinity (mg/l)	pH	Chloride (mg/l)	sulphate (ppm)	Total hardness(mg/l)	TDS (mg/l)	TSS (mg/l)
200	6.5-8.5	250	200	200	500	25

These are the maximum permissible limits values.

3. RESULTS AND DISCUSSION

3.1 Seasonal Changes of Physico-Chemical Parameters

3.1.1 Alkalinity

The alkalinity was higher during monsoon and summer season in all tanks and low in winter season comparatively (Fig. 2). The alkalinity was high in monsoon due to rainfall may leach acidic materials from agricultural land and summer due to increase in bicarbonates in the water, it was maximum in summer and minimum in winter due to high photosynthetic rate [9]. Among different tanks the highest alkalinity was observed in Krishnampathy tank followed by Selvampathy tank and Kumaraswamy tank. The lowest value was observed in Perur tank followed by Narasampathy tank. The highest alkalinity in Krishnampathy was due to more industries situated around this tank as well as the TNAU-STP outlet also let into the tank. Even though the alkalinity values of all the tanks were found to be within the maximum limit of CPCB standard for drinking water, the values were in the upper end of the maximum permissible limits. Similar results were obtained in a study and compared it with World Health Organization standards [10]

3.1.2 pH

The pH was increased during the summer and winter seasons in all tanks and it was low in monsoon season (Fig. 3). The highest pH was observed in Narasampathy tank followed by Selvampathy tank and Perur tank in both summer and winter. The lowest value was observed in Kumaraswamy followed by Krishnampathy during Monsoon. The Higher pH in Narasampathy tank was due to the entry of domestic waste water into the tank without any sort of treatment. pH values of all tanks were found to be within the maximum permissible limits of CPCB standards for drinking water. Our results are in agreement with the study of Garba *et al.*, [11].

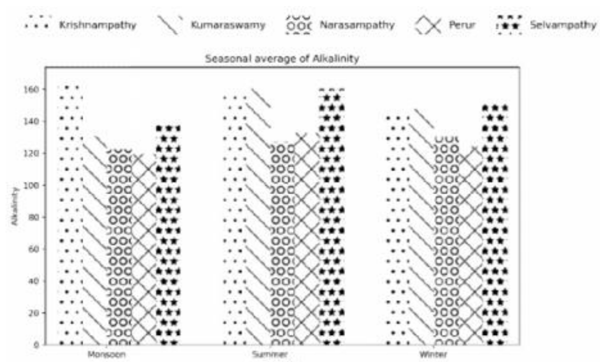

Fig. 2. Seasonal average of alkalinity

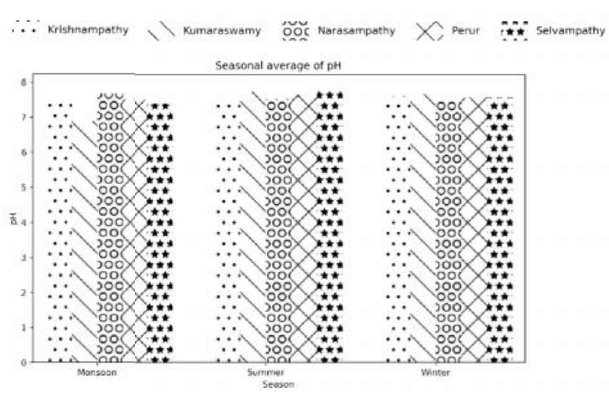

Fig. 3. Seasonal average of pH

3.1.3 Electrical conductivity (EC)

During summer and winter season Electrical Conductivity was high in all tanks and low in Monsoon season (Fig. 4). Among different tanks the highest EC was observed in Perur tank followed by Selvampathy and Krishnampathy tank. The lowest value of EC was observed in Narasampathy tank followed by Kumaraswamy tank. The higher Electrical Conductivity in Perur was due to the presence of more dissolved solids and other inorganic chemicals. EC values of all the tanks were found to be within the maximum permissible limits of CPCB standards for drinking water. In a study on water conductivity, general water quality was determined by EC of the sample [12].

3.1.4 Chloride

All the seasons the Chloride was high in Krishnampathy and Selvampathy tanks and lower in all other tanks (Fig. 5). Among different tanks the highest Chloride was observed in Krishnampathy tank followed by Selvampathy tank. The lowest value was observed in the Narasampathy tank followed by Perur tank and Kumaraswamy tank. The highest chloride in Krishnampathy was due to more industries situated around this tank and discharge the effluents into the tank. The chloride values were beyond the maximum permissible limits of CPCB in Krishnampathy and selvampathy tanks. But the Chloride Concentration was in the upper end of the maximum permissible limits in Narasampathy, Perur and Kumaraswamy tanks for drinking water. Similar results for chloride were observed in Subarnarekha River during winter [13].

3.1.5 Sulphates

During all the seasons Sulphates was low in all tanks and within the maximum permissible limits of CPCB standard for drinking water and were near the lower end of the maximum permissible limits (Fig. 6). Sulphates were within the acceptable limit for Malaysian rivers and were categorized as class I range based on the National Water Quality Standards [14]. In these areas, farmers use fertilizers containing sulphate, and it finally reaches the streams through surface runoff and irrigation waters [15].

3.1.6 Total hardness

Total hardness was high in all tanks and among the different tanks the highest hardness was observed in Narasampathy tank followed by Krishnampathy tank, Kumaraswamy tank, Selvampathy tank and Perur tank (Fig. 7). High hardness in water may be due to more salts in the effluents let out from industries and semi-urban inhabitants' areas as well as the lithology of the study area which contains more limestone in the parent rock. Total hardness of all tanks was found to be exceeding the maximum permissible limit of CPCB standards for drinking water. The urbanization, increased population and more industries in the Noyyal basin decreased the water quality and increased the pollution load [16].

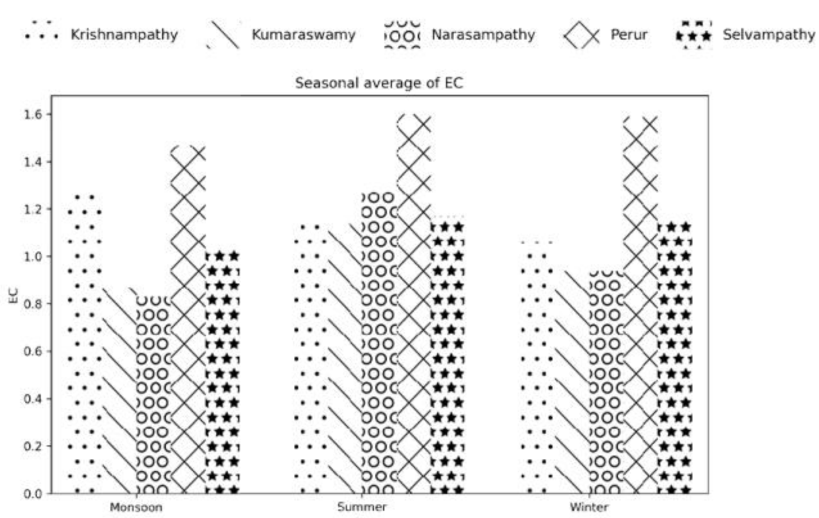

Fig. 4. Seasonal average of electrical conductivity

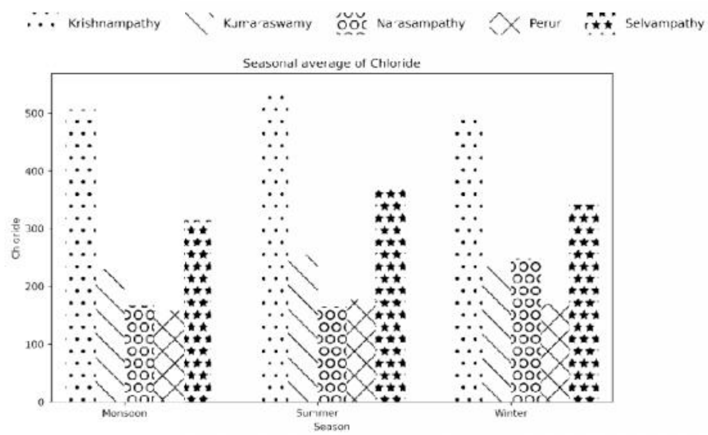

Fig. 5. Seasonal average of chloride

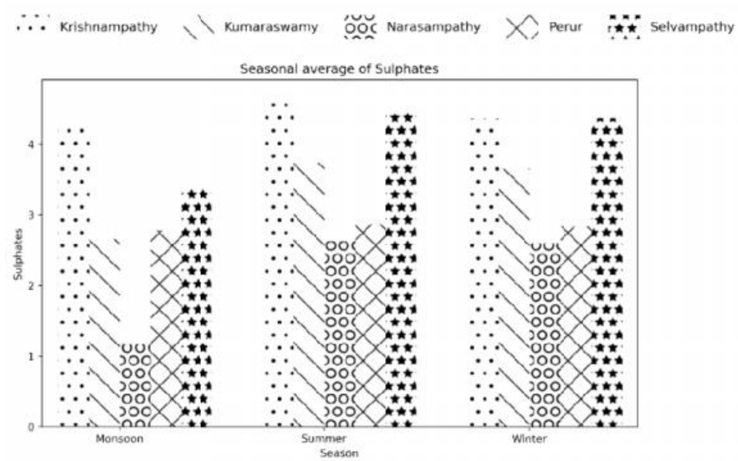

Fig. 6. Seasonal average of sulphates

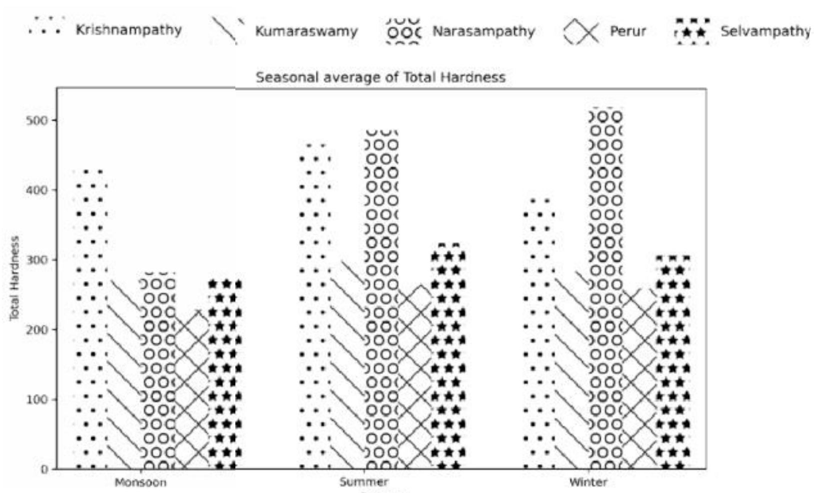

Fig. 7. Seasonal average of total hardness

3.1.7 Total Dissolved Solids (TDS)

The TDS in the water was higher in all tanks in all seasons. The highest value was observed in Perur tank followed by Krishnampathy, Narasampathy, Selvampathy and Kumaraswamy tanks (Fig. 8). The higher TDS might be due to the entry of various chemicals,entry of domestic wastewater and agricultural runoff from the surrondings. The values of TDS ranged exceeding the maximum permissible limits of CPCB standards for drinking water. During summer the TDS was higher, it was due to less or no inflow water from the river. Same results were observed by Rajan, D.S and Samuel, S.M. [17] in Achenkovil River during post monsoon period.

3.1.8 Total Suspended Solids (TSS)

TSS was high in all tanks and the highest value was observed in Krishnampathy tank followed by Selvampathy, Narasampathy and Kumaraswamy tanks (Fig. 9).

The higher TSS might be due to solid waste of domestic waste water from household, hotels, hostels and other inhabitants areas as well as effluent from small scale industries into these tanks.many tank embankments are filled with solid waste leading to the increase of TSS in those tanks. The values of TSS ranged exceeding the maximum permissible limits of CPCB standards for drinking water. High values of TSS may represent the high susceptibility of the soil to erosion [18]. The tremendous increase in the TSS may drastically affect the stability of the embankments of the tanks.

3.2 Correlation Analysis

From the correlation analysis, we could observe that all the parameters are correlated with one another, which depicts the relationship between these parameters and water quality analysis (Fig. 10).

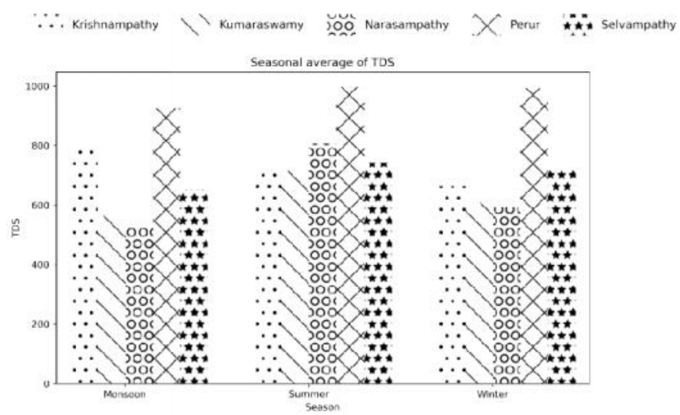

Fig. 8. Seasonal average of TDS

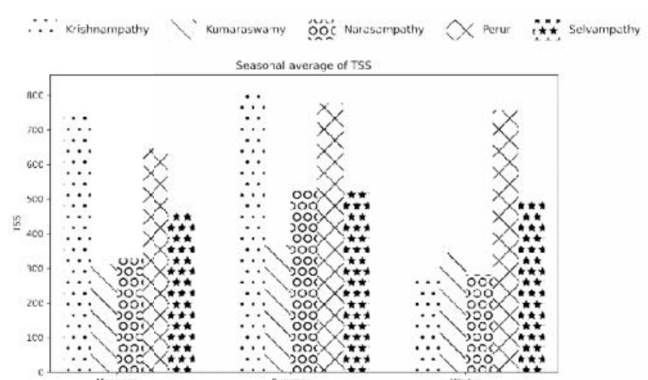

Fig. 9. Seasonal average of TSS

There is a high positive correlation between EC and TDS (0.99) followed by Alkalinty and Sulphates (0.64), Chloride and Sulphates (0.57),Alkalinity and Chloride (0.55), and no or less correlation was found in TDS and Total hardness (0.21), Alkalinity and TSS (0.26), TDS and Sulphates (0.29), Sulphates and EC (0.29), Total hardness and Sulphates (0.34), Sulpahtes and TSS (0.35), Alkalinity and EC (0.36), Alkalinity and TDS (0.37), Alkalinity and Total Hardness (0.4), EC and TSS (0.45), TDS and TSS (0.45), Total hardness and Chloride (0.45). We could not find any negative correlation between these paramters. Since, the EC and TDS are representing the salts concentration of the water had a high correlation . Same type of correlation analysis was observed between water samples parameters [19].

3.3 Anova Analysis Based on Seasons

Anova analysis was performed for the physico-chemical parameters of all tanks between the seasons with a sample size of 195 for each season by using SPSS software and from which the results can be concluded that the summer season has an increased chemical parameter than the Winter and Monsoon season. TSS is high in monsoon season due to the runoff obtained from the rainfall event, which tend to increase the Suspended matter content in the incoming runoff water. Anova tests whether the parameters the means is equal or not. From the anova results, it is clear that the chemical parameters have high significance between the groups except Chloride. Anova results showed that the there is a significant relationship between seasons and water quality parameters. This is in accordance with the study of Akbulut *et al* ,2010.

3.4 Anova Analysis Based on Tanks

Anova analysis was performed for the physico-chemical parameters between the tanks with a sample size of 117 for each tank by using SPSS software. The ANOVA creates an F-statistic, which is the ratio of the variance calculated among the means to the variance within the samples. From the results, it is clear that all the chemical parameters have high significance between the groups in tank wise analysis. Two-way ANOVA test results showed that interaction effects of any variables (Akbulut *et al*2010).

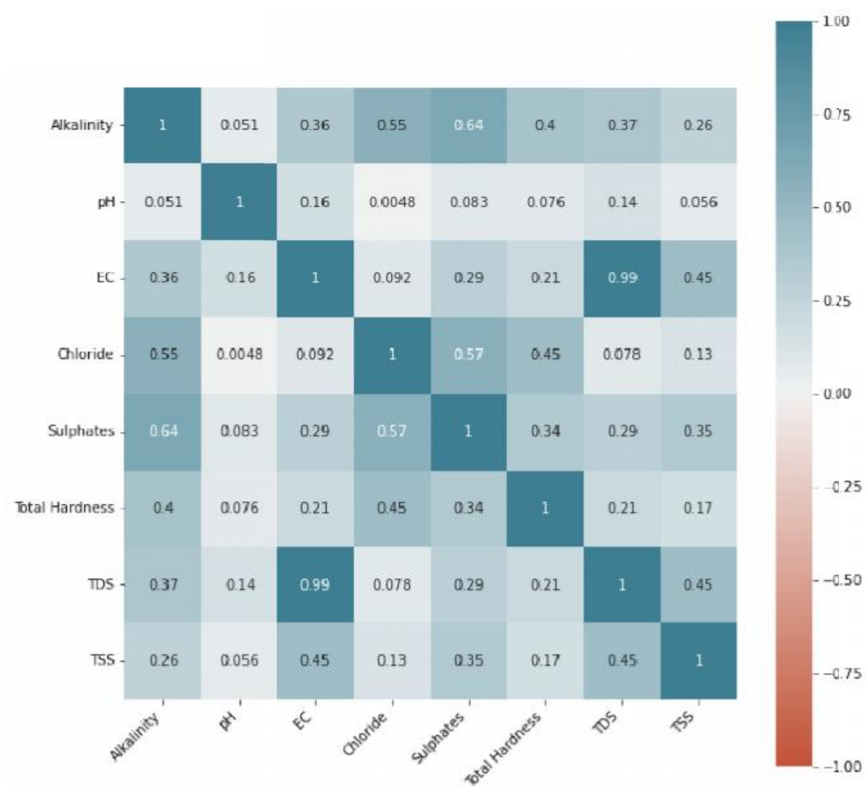

Fig. 10. Correlation analysis of tanks

Table 2. Anova analysis based on seasons

Chemical Parameters	Seasons	Mean	Std. Deviation	F-Value	P-value
Alkalinity	Winter	135.26	30.59		0.00
	Summer	140.20	28.93	9.390	
	Monsoon	148.07	28.81		
	Total	141.18	29.87		
pH	Winter	7.60	0.27		0.00
	Summer	7.65	0.32	27.229	
	Monsoon	7.40	0.46		
	Total	7.55	0.37		
EC	Winter	1.13	0.35	13.530	0.00
	Summer	1.27	0.33		
	Monsoon	1.09	0.37		
	Total	1.17	0.36		
Chloride	Winter	297.95	137.08	2.058	0.129
	Summer	303.38	152.65		
	Monsoon	275.48	141.85		
	Total	292.27	144.27		
Sulphates	Winter	3.57	1.36	19.554	0.00
	Summer	3.68	1.35		
	Monsoon	2.86	1.49		
	Total	3.37	1.44		
Total Hardness	Winter	352.05	150.40	13.668	0.00
	Summer	368.94	154.31		
	Monsoon	298.93	103.38		
	Total	339.97	140.95		
TDS	Winter	716.17	217.07	12.484	0.00
	Summer	796.79	202.46		
	Monsoon	692.86	226.44		
	Total	735.27	219.75		
TSS	Winter	431.69	233.56	26.669	0.00
	Summer	603.59	232.93		
	Monsoon	502.13	234.53		
	Total	512.47	243.73		

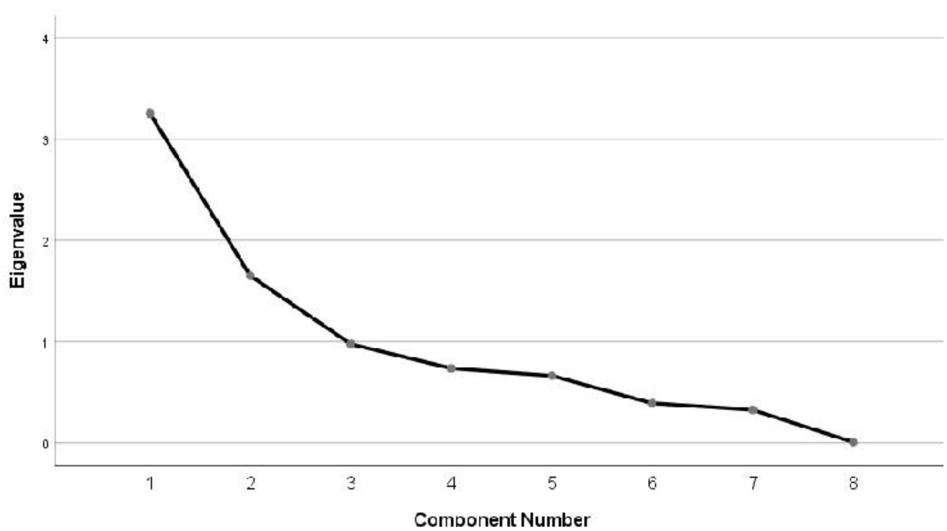

Fig. 11. Screen plot of eigen values versus components

Table 3. Anova analysis based on tanks

Chemical parameter	Tanks	Mean	Std. Deviation	F- Value	P- Value
Alkalinity	Krishnampathy	157.60	25.84	32.543	0.00
	Narasampathy	126.76	22.81		
	Selvampathy	149.56	30.98		
	Kumaraswamy	146.35	30.95		
	Perur	125.62	23.75		
	Total	141.18	29.87		
pH	Krishnampathy	7.44	0.49	4.229	0.002
	Narasampathy	7.59	0.28		
	Selvampathy	7.58	0.38		
	Kumaraswamy	7.53	0.35		
	Perur	7.62	0.31		
	Total	7.55	0.37		
EC	Krishnampathy	1.16	0.32	70.33	0.00
	Narasampathy	1.02	0.26		
	Selvampathy	1.12	0.34		
	Kumaraswamy	0.98	0.16		
	Perur	1.55	0.35		
	Total	1.17	0.36		
Chloride	Krishnampathy	514.57	39.65	475.564	0.00
	Narasampathy	193.59	71.98		
	Selvampathy	343.75	106.80		
	Kumaraswamy	239.96	73.24		
	Perur	169.50	31.01		
	Total	292.27	144.27		
Sulphates	Krishnampathy	4.45	1.38	73.198	0.00
	Narasampathy	2.13	0.95		
	Selvampathy	4.08	1.66		
	Kumaraswamy	3.35	1.09		
	Perur	2.83	0.47		
	Total	3.37	1.44		
Total Hardness	Krishnampathy	430.09	121.19	58.296	0.00
	Narasampathy	430.06	219.88		
	Selvampathy	303.20	81.07		
	Kumaraswamy	284.98	28.09		
	Perur	251.53	30.62		
	Total	339.97	140.95		
TDS	Krishnampathy	725.82	205.71	68.086	0.00
	Narasampathy	642.58	165.07		
	Selvampathy	706.35	210.94		
	Kumaraswamy	629.19	92.55		
	Perur	972.43	206.89		
	Total	735.27	219.75		
TSS	Krishnampathy	618.82	268.65	79.287	0.00
	Narasampathy	379.49	167.32		
	Selvampathy	494.56	208.26		
	Kumaraswamy	341.73	167.54		
	Perur	727.76	147.43		
	Total	512.47	243.73		

3.5 Principal Component Analysis

Principal Component Analysis can be applied on large samples, for data reduction and interpreting the patterns within the dataset in order to provide data.it has been carried out to find out the important factors affecting the quality of the tank water. Based on the eigen values screen plot, the parameters were reduced to 2 main factors (component I and component II). From the PCA analysis we can able to observe that the major water quality parameters in the study under the component I are Alkalinity, EC, Sulphates, Total Hardness, TDS and TSS and the component II includes pH and Chloride respectively in Table 4.PCA showed the parameters contributing for the water quality from the [7].

3.6 Heavy Metal Analysis

Heavy metal pollution in water resources can affect the public health directly through drinking water and agricultural activities through irrigation using contaminated water, such as polluted river water, treated and untreated industrial and domestic wastewater. During winter season the range of Heavy metals are in a moderate level, due to the minor inflow from the Noyyal river and the rate of heavy metals may be due to these sediments in these tanks. The range of Zinc in these tanks varied from 0.8 to 1.026, which was within the permissible limit. Industries liquidating of raw untreated form of transparent liquid wastes directly into the river [20]. The range of copper in these tanks is above the permissible limit of 0.05 mg/l. The range of cadmium is more than the permissible limits in those tanks except the selvampathy tank. The range of Lead in these tanks exceed the permissible limits of the CPCB standard. These increase in the load of heavy metals in the tanks are due to various activities like metallurgy, dyeing, casting and electroplating which are taken place in these areas and the waste water generated from these processes are directly diverted to these tanks without any sort of treatments The similar results was observed in lower reach of the Amaravathi River have high Cd due to the industrial activities, widely used in electroplating and also from pigments (Ahamed and Loganathan,2017).

The surface water tanks, which are in the urban catchments of the study area, the activities like Electro plating, dyeing and jewel making are predominant and because of which the urban tanks like Krishnampathy, Kumaraswamy, Selvampathy are more prone to the deposition of heavy metals. Even the Noyyal river is affected by these processes, which makes the downstream more polluted making the downstream dam of Noyyal, Orathupalayam dam non utilizable for the people of Tiruppur. Heavy metals are present in high amounts in untreated sewage and are not destroyed during the treatment process [21].

Table 4. Loadings of experimental variables on principal component analysis

	Component	
	I	II
Alkalinity	.764	.338
pH	.179	-.182
EC	.752	-.599
Chloride	.571	.650
Sulphates	.734	.376
Total Hardness	.550	.365
TDS	.752	-.601
TSS	.584	-.291

Table 5. CPCB standards -permissible limit of Heavy metal in drinking water

Zinc (mg/l)	Copper (mg/l)	Cadmium (mg/l)	Lead (mg/l)
5	0.05	0.003	0.01

Table 6. Heavy metals in winter season

SAMPLING POINTS	Zinc (mg/l)	Copper (mg/l)	Cadmium (mg/l)	Lead (mg/l)
RIVER WATER	0.8	0.04	0.0058	0.444
KRISHNAMPATHY	0.996	0.062	0.0062	0.728
NARASAMPATHY	0.985	0.058	0.008	0.802
KUMARASWAMY	0.997	0.098	0.088	1.2
SELVAMPATHY	1.026	0.114	0.02	1.54
PERUR	0.965	0.055	0.0045	0.471

Table 7. Heavy metals in monsoon season

SAMPLING POINTS	Zinc (mg/l)	Copper (mg/l)	Cadmium (mg/l)	Lead (mg/l)
RIVER WATER	0.654	0.04	0.0015	0.23
KRISHNAMPATHY	0.712	0.065	0.0026	0.35
NARASAMPATHY	0.645	0.044	0.0021	0.29
KUMARASWAMY	0.745	0.071	0.003	0.4
SELVAMPATHY	0.768	0.084	0.016	0.46
PERUR	0.667	0.051	0.0019	0.25

Table 8. Heavy metals in summer season

SAMPLING POINTS	Zinc (mg/l)	Copper (mg/l)	Cadmium (mg/l)	Lead (mg/l)
RIVER WATER	1.002	0.057	0.006	0.76
KRISHNAMPATHY	1.214	0.092	0.0078	1.24
NARASAMPATHY	1.066	0.074	0.007	0.92
KUMARASWAMY	1.513	0.122	0.101	2.41
SELVAMPATHY	1.655	0.165	0.016	3.02
PERUR	1.054	0.069	0.0068	0.9

Zinc heavy metal load in all tanks including river water were in safe limit. Momin *et al*., [22] also found that the zinc was less than the permissible limit in their study. The copper concentrations in the river water and Narasampathy tank were within the permissible limits and all the tanks it exceeded the safe limit and made the water unfit for drinking purpose. The Cadmium heavy metal pollution was within the safer limits during monsoon period. Cadmium concentration was less than the permissible limits of the Ajay River basin [23]. Lead metal concentration was very high during monsoon period also. Uzma Imran *et al,* [24] revealed that the cadmium and lead average concentrations exceeded acceptable limits in at least one season.

During summer period, even though we observed increased concentration of zinc in the river as well as in the surface tank, but the values are within the safe limits of CPCB. Copper in these tanks were exceeding the permissible limit with two to three-fold increased than the safe limit. The second most major metal in water was Copper, which was found higher in summer season as compared other seasons [13]. Likewise, the cadmium metal was also increased up to five-fold than the permissible limit of 0.003 mg/l. In case of lead concentration was increased many folds in the tanks than the permissible limits. Krika *et al,* 2017 reported that the concentrations of the Cd, Pb and Cu were above the permissible limits in all samples in the study. The increase in metal concentration was due to the less water fed by Noyyal river to these tanks and the river is seasonal during off season the water evaporation with no dilution effect caused more concentration of the heavy metal concentration.

4. CONCLUSION

From the water quality analysis and the correlative analysis, it was clear state that most of the parameters were exceeding the permissible limits of the CPCB standards and correlative analysis shows that these parameters had an impact on the quality of surface water. High water hardness was due to the presence of high mineral content and high EC and TDS was due to the higher salts content in water. High TSS influenced by more sand, silt, clay, mineral precipitates, and biological matter due to human activities in and around the tank. Comparatively the Narasampathy tank was less polluted, since it is the first tank of upper reach of the Noyyal river and also has very less inhabitants around the tank. During summer season, it was observed that the water was stagnant or water level in the tanks are low mainly due to the less inflow from Noyyal, evaporation and heavy water overdraft, due to which the water quality parameters were more than the permissible limits of CPCB standards in summer.

The range of heavy metals were above the permissible limits except zinc was due to the varying inflow of Noyyal river water into these tanks. Heavy metal study concluded that the industrial activities like electroplating, smelting, jewelry making, dyeing were the reasons for the high concentration of heavy metal in this upper reach of Noyyal river basin surface tanks and it may vary based on the seasons depending on the inflow into the tanks. Moreover, seasonal variation had significant effects on the concentration of heavy metals in the sediment. The concentrations of heavy metals were higher in summer, spring, and winter than in autumn [25].

This surface tanks were flooded with domestic and urban waste waters led to the complete devastation of the quality of tank water. The inadequate sanitary urban infrastructure and the lack of control of the pollution and untreated domestic and industrial waters were released to the surface water tanks led to worsening of the present status of the surface tanks. Dumping of solid waste, connection of untreated sewage into the surface runoff drainage and other anthropogenetic events were the reasons for the deteriorating quality of the lake [26]. These could be rectified only, when the waste water entering into the tanks would be diverted to the decentralized waste water treatment plant and the water must be treated and let in to the surface water tanks to decrease the rate of pollution and save the flora, fauna and the environmental status of these tanks. Anova table depicts the relationship water quality parameters with the tanks and seasons.PCA describes the relationship between these water quality parameters and have categorized them into two components. So, it is necessary to continuously monitor the water quality of tanks to implement the mitigation measures for the deteriorating water in the tanks in the upper reach of Noyyal river basin. Awareness about the recycling and reuse of waste water in the domestic level may be popularized among the society and to find out the potential pollution sources in the study area and to strictly implement the pollution norms to preserve the natural waters for the future usage. Strict treatment of domestic waste water entry into the tanks to decrease the pollutant load is much needed at this situation to prevent the harmful effects on environment. Recommendations were suggested based on source of pollutant and drinking water standards of the parameters and the depending upon the Land use [27]. We concluded that our study can be used to implement policies and solutions for improving the water quality in the surface water tanks in the upper reach of Noyyal river basin for sustain the water resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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