ASSESSMENT OF POLLUTANTS AND ITS INFLUENCE OF OUTFLOW ON THE DOWNSTREAM OF MUSI RIVER, HYDERABAD

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Abstract: This study provided a comprehensive assessment of pollutants in the Musi River, Hyderabad and the influence of outflow on the downstream during post-monsoon, monsoon and pre-monsoon seasons. The water samples on monthly basis from 6 monitoring stations consisting of physicochemical and bacteriological parameters were downloaded from Telangana State Pollution Control Board website for the period Jan 2020 to Mar 2021. Seventeen surface water samples data for pre-monsoon, monsoon and post-monsoon were subjected to ANOVA test to study the seasonal variations of these parameters. The analysis showed a significant seasonal difference ($P < 0.05$) in the parameters like EC, COD, BOD, Hardness, Calcium, Magnesium, Sulphate, Potassium, sodium and turbidity. The results of correlation analysis showed that EC has a strong positive correlation with Chloride, Hardness, sodium and TDS. BOD has strong positive correlation with COD and Potassium, indicating that solid concentration of waste and sewage water may the reason for high values BOD. Hardness is correlated with calcium and magnesium indicating that the precipitation of soap scum and excess usage of soap for cleaning purpose may be the reason for recorded high concentration values. The cluster analysis showed that the monitoring locations can be grouped into two clusters based on the physicochemical analysis data, and these two clusters can be classified as relatively low and high pollution areas. The overall results indicated that some of the sampling locations in the Musi River are heavily contaminated with pollutants from various sources which can be correlated with anthropogenic activities.

Introduction:

Earth's surface water- bodies are generally the most recognisable part of water cycle. Interference of human activities with water cycle often affects the society – water relationship. Surface water was continuously susceptible by human caused activities. Now a day's river contamination with hazardous wastes becoming a common problem and this due to rapid development in urbanization and industrialization [Ali, 2012]. The rapid urbanisation and industrialisation generate waste water without any proper treatment or re-use. Especially in urban cities, with high population density generates large quantity of wastewater, which is discharged to the water resources without proper treatment. As a result, the surface water is contaminated by both natural processes and anthropogenic activities. These water resources will act like pathways for the dissemination of toxic and pathogenic microorganisms. So, evaluation of such water resource and identifying the source(s) of contamination is very essential in the view of minimizing the public health risks.

Many researchers have reported the evaluation methods/reasons for assessing the quality of surface water. The quality of water was determined by physical, chemical and biological compositions [Allee and Johnson, 1999]. The point and non-point sources of pollution in a region were affecting the surface water quality [Nnane et al., 2011]. In order to understand the sources of pollution, a strategic mechanism of monitoring systems have to be developed [Marale, 2012; Ouyang, 2005]. The entries of these sources are needed to be addressed for protecting the population from waterborne diseases and to develop appropriate methods for prevention of these pollutants. Hence the environmental systems like rivers, lakes etc., are affected by these pollutants through multiple sources, so it is important to study the variations of these pollutants spatially and temporally for identifying the possible sources/factors that influence the water systems [Shrestha and Kazama, 2007; Singh et al., 2005; Ogwueleka, 2015].

Hyderabad, also known as Pearl City and city of lakes, is the capital city of Telangana state. It is the fourth –most populous city in India with a population of 10 million, covering an area of 625 square kilometres. The city stands on the banks of Musi River, also called as Musinuru, a tributary of river Krishna, and divides the historical city into old and new city. The river originates from Ananthagiri hills, near Vikarabad district and flows into Krishna River at Wedapally in Nalgonda district after traveling a total length of 240 km. The river has good discharge and quality in the upstream, but as it flows through the city and reach downstream, it looks like a giant sewage drain, filled with garbage and industrial waste. This may be due to indiscriminate urbanisation and not having proper plan. Now it is one of the most polluted rivers in India. The residents in the downstream villages have experienced serious public health issues like high incidence of diseases such as diarrheic, skin allergies, stomach pain, malaria, eye diseases, paediatric problems and jaundices in the year 2012 [Pullaiah, 2012].

The raising problem of pollution has demanded to monitor the quality of water. Recent studies showed that Musi River is heavily contaminated with pollutants from domestic sewage, industrial effluents and farmlands, which substantially give impact on the quality of surface and ground water [Pullaiah, 2012; Sujatha ; 2016; Pears et al., 2016; Hussain and Sharma, 2020]. Therefore, it is important to assess the pollutant type connecting to this river to prevent the entry of the polluted water and provide measures for improving the quality of water and environment in and around the Musi. In this study, we provided a comprehensive assessment of pollutants in the Musi River based on the physicochemical and microbiological data with a statistical approach. The results obtained in this study will be useful to assess the significant impact of pollutants on the water quality and to identify the pollution type within the river for better monitoring and management.

Study area:

Hyderabad is the hub of IT industries and due to its geography, a large number of industries and multi-national companies are established in the city. Due to this rapid growth of urbanization many people are migrated to Hyderabad from the entire country. This study was carried out over Musi River, which is one of the most polluted rivers in India that crosses the Peral city of Hyderabad. Now it is acting like a sewage channel in the city with a length of 57 km before joining the Krishna River. The waste input to the river is mostly from the drains and industries. The river collects water from the population of approximately 6.5 million residents primarily collected along the river stream. In Hyderabad city daily around 600 million litres of untreated sewerage get discharged in to the river [Sujatha, 2016]. Furthermore, upstream flows though the city and the downstream flows through the agriculture area. The water quality of a given river is the result of interdependence of various parameters with a spatial and temporal variation of these parameters. Human activities have great influence on river ecosystem with particularly in what concerns the water resources, quantity and quality.

A network of monitoring stations established by Telangana State Pollution Control Board (TSPCB) comprises of 11 sampling sites. The monitoring is done on monthly basis on surface water. The water samples are being analysed for 28 parameters consisting of physicochemical and bacteriological parameters for ambient water samples. These parameters on monthly basis are made available in the Central Pollution Control Board (CPCB) website (www.cpcb.nic.in) under National Water Quality Monitoring Programme (NWMP). In our present study, we have used data of 6 sampling stations, which were downloaded from the website for the period Jan 2020 to Mar 2021 as mentioned in the Table 1. The following are the Physicochemical and Bacteriological parameters that were used in the present study: pH, BOD, COD, electrical conductivity (EC), Sulphate, Nitrate, calcium, magnesium, sodium, potassium, chloride, hardness, turbidity, fecal coliform, TSS, and TDS. To investigate the seasonal effect on water quality parameters we divided the available data into three season's pre-monsoon (March, April and May); monsoon (June, July and August); Post-monsoon (September, October and November).

Statistical Analysis:

The physicochemical and bacteriological parameters over Musi River were analysed using one-way analysis of variance (ANOVA) test to study the seasonal variation of these parameters. Correlation analysis was performed to determine the relation between all the parameters in the Musi River during each season using Spearman's non parametric rank correlation test with 5 % significance level. The data transformation and analysis were done using Matlab software.

Results and Discussion:

Surface water quality of Musi River

The surface water quality parametric analyses from six sampling locations over Musi River across three seasons are summarized in Table 1 and the corresponding temporal variations were shown in Figure 1-4. The table shows the concentration levels of these parameters during pre-monsoon, monsoon and post-monsoon seasons.

According Indian standards, the natural water systems require a pH range of 6.5 – 8.5 for sustainability of aquatic population. The pH values of water samples of Musi River during pre-monsoon, monsoon and post-monsoon seasons lie within the permissible limits. In pH concentration there is no significant statistical differences across different seasons ($p > 0.05$) (Figure 1).

The electrical conductivity values of the sampling exceed the standard value 1000µS/cm in all seasons. The values are ranged between 1333 µS/cm to 1586 µS/cm; 1213 µS/cm to 1273 µS/cm and 1008 µS/cm to 1570 µS/cm in pre-monsoon; monsoon and post- monsoon seasons respectively. The elevated levels of EC above standard value indicate that the water bodies are polluted due to heavy sewage or waste water. The EC values are not varied significantly with seasons.

The concentration of BOD can be used to assess the strength of sewage and amount of organic matter. The BOD values across all the seasons exceed the permissible limits with significant statistical differences ($p < 0.05$). The maximum and minimum values of BOD were observed in pre-monsoon and post-monsoon respectively. As BOD value exceed 8mg/L, Musi River can be classified as the most polluted river. The nitrate values in all the seasons were found to be within the permissible limits ranging between 1.47 to 14.19 mg/L.

The higher values of Fecal Coliform (FC) were observed in all seasons with maximum in post monsoon and minimum in pre-monsoon. The high levels of FC in post-monsoon may be due heavy rainfall during monsoon. The increased levels on Fecal after the rainfall events have been widely acknowledged in scientific literature. The FC levels not showed any significant difference across seasons.

Our results reveals that the chloride concentration is not exceeded Indian standards. Chemical Oxygen Demand (COD) is a significant water quality parameter same as BOD which provides an index to assess the solid concentration of waste and sewage water. The COD values show a significant seasonal variation ($p < 0.05$). The mean COD value was found to be comparatively high in pre-monsoon than compared to other two seasons and there were less than standard value (250mg/L). Hardness in water was caused due to dissolved calcium and magnesium. The concentration of Hardness varies from 287 to 417 mg/L; 267 to 343 mg/L and 238 to 353 mg/L during pre-monsoon; monsoon and post-monsoon respectively. In the all seasons the hardness surpasses the standard value. The high value indicates that the precipitation of soap scum and excess usage of soap for cleaning purpose as river passes through high dense residential areas.

The calcium and magnesium levels during all the seasons were found to exceed the standard values. The values of sulphate concentrations showed a significant seasonal difference with $p < 0.05$. However, these values lie below the specified limits in all the seasons. The observed Sodium concentration values were found to increase gradually from pre-monsoon to post-monsoon. TDS values of Musi River were much higher than standard value (500mg/L) in all seasonal, whereas, they were well within desirable limits. TSS values are recorded very low. There is a significant seasonal variation of potassium levels with $p< 0.05$. Turbidity is the measure of clearness of water. The high value (exceeding standard values) of turbidity was noted in all seasons with a significant difference across all seasons.

The results of correlation analysis (Table 2) showed that EC has a strong positive correlation with Chloride, Hardness, sodium and TDS. BOD has strong positive correlation with COD and Potassium, indicating that solid concentration of waste and sewage water may the reason for high values BOD. Hardness is correlated with calcium and magnesium indicating that the precipitation of soap scum and excess usage of soap for cleaning purpose may be the reason for recorded high concentration values.

A dendrogram of the hierarchical binary cluster tree generated by the linkage function of the 6 locations into two clusters at 70% of the maximum linkage is shown in Figure 5. The results are convincing, as the generated clusters share similar characteristic features. Cluster 1 includes four locations (Locations 1 and 4-6) and consists of mixed land use, either rural or urban/suburban residential areas with little industrial activity, corresponding to a relatively low level of pollution. Cluster 2 comprises two locations (2 and 3) are predominantly close to urban residential areas with large-scale business, dumping and entry of drainage and wastewater activities into the river. This cluster was classified as highly polluted based on the physicochemical and microbiological results. The result enabled us to categorize locations based on water quality, so that in future studies, the number of locations can be minimized for cost-effective monitoring of water quality in Musi River by choosing a few locations from each cluster based on the distance distribution and pollution levels in those locations. Previous studies have reported that a similar strategy has been successfully applied in water quality monitoring programs elsewhere [Shrestha and Kazama, 2007; Singh et al., 2005; Pejman et al., 2009; Phung et al., 2015].

Conclusions

In this study, a detailed physicochemical and microbiological water polluting parameters were assessed for quality of Musi River water. The results indicate that the parameters BOD, Nitrate, COD, Sulphate, Potassium and Turbidity shows the significant seasonal difference ($p<0.05$) in this river. A higher value of COD indicates that the river water contains higher levels of oxidisable material which will reduce dissolved oxygen levels in the river water. The physicochemical parameters such as Chloride, Hardness, Sodium and TDS are highly correlated with Electrical Conductivity. The high values of BOD indicate that solid concentration of waste and sewage water influenced to have a strong positive correlation with COD. The cluster analysis showed that the station can be grouped into two clusters based on physicochemical and microbiological analysis data. The overall analysis showed that the possibility of contamination of the river is due to various sources which can be correlated with solid wastes and the sewage water. This research can aid in the effective implementation of a strategic monitoring programme for water quality.

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References:

1. Allee, R J, and Johnson, J E, 1999. Use of satellite imagery to estimate surface chlorophyll a and Secchi disc depth of Bull Shoals Reservoir, Arkansas, USA. Int. J. Remote Sens. 20, 1057–1072. doi: 10.1080/0143116992 12849.
2. Nnane, D.E.; Ebdon, J.E., Taylor, H.D. 2011. Integrated analysis of water quality parameters for cost-effective faecal pollution management in river catchments. Water Res. 2011, 45, 2235–2246.
3. Marale, S. 2012. Shifting role of ecology in solving global environmental problems: selected practical tools. Environ. Develop. Sustain. 14, 869–884. doi: 10.1007/s10668-012-9362-8.
4. Ouyang, Y. 2005, Evaluation of river water quality monitoring stations by principal component analysis. Water Res. 39, 2621–2635.

5. Shrestha, S.; Kazama, F. 2007, Assessment of surface water quality using multivariate statistical techniques: A case study of the fuji river basin, Japan. Environ. Model. Softw. 22, 464–475.
6. Singh, K.P.; Malik, A.; Sinha, S. 2005, Water quality assessment and apportionment of pollution sources of Gomti river (India) using multivariate statistical techniques—A case study. Anal. Chim. Acta 538, 355–374.
7. Ogwueleka, T.C. 2015. Use of multivariate statistical techniques for the evaluation of temporal and spatial variations in water quality of the Kaduna River, Nigeria. Environ. Monit. Assess. 2015, 187, 137
8. Pullaiah C. 2012. Musi River Pollution Its Impact on Health and Economic Conditions of Down Stream Villages-A Study,OSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) ISSN: 2319-2402, ISBN: 2319-2399. Volume 1, Issue 4, PP 40-51.
9. K. N. Sujatha, 2016. Assessment of Musi River Water and Nearby Ground Water: Impacts on Health of Down Stream Villages of Hyderabad, Indian Journal of Science and Technology, Vol 9(34). doi: 10.17485/ijst/2016/v9i34/99172.
10. Ali, J. 2012. An Assessment of the Water Quality of Ogunpa River Ibadan, Nigeria. M.Sc. Dissertation. University of Ibadan, Ibadan, Nigeria, Pp. 32 – 41.
11. Pejman, A.H.; Nabi Bidhendi, G.R.; Karbassi, A.R.; Mehrdadi, N.; Bidhendi, M.E. 2009, Evaluation of spatial and seasonal variations in surface water quality using multivariate statistical techniques. Int. J. Environ. Sci. Technol. 6, 467–476.
12. Phung, D.; Huang, C.; Rutherford, S.; Dwirahmadi, F.; Chu, C.; Wang, X.; Nguyen, M.; Nguyen, N.H.; Do, C.M.; Nguyen, T.H.; et al. 2015,Temporal and spatial assessment of river surface water quality using multivariate statistical techniques: A study in Can Tho City, a Mekong Delta area, Vietnam. Environ. Monit. Assess. 187, 229.

13. Pears, B., C.V.V. Prasad , Dr. M. Chandra Sekhar, 2016. Assessment of Water Quality Status of Musi River – A Tributory of River Krishna in India, International Journal of Engineering Science and Computing, pg.3415-3422.

14. Mohammed Zakir Hussain and Ravi Kant Sharma, 2020. Study of Contaminants Index of Musi River Command Area, Biosc. Biotech. Res. Comm. Special Issue Vol 13, No 15, pp-197-199.

Table 1. Stations codes and Station names

Station code	Station name
4253	Musi sample at Bapughat sangam U/S of Musi
4656	River Musi at Moosarambagh bridge, Hyderabad
2339	River Musi at Nagole
4659	Outlet of Nalla Cheruvu, Peerajadiguda
4660	River Musi at Peerajadiguda
1173	D/s. of Musi at Pratapasingaram

Table 1. Maxima and Minima values and their significance for different water pollutants

Parameter	Pre-monsoon		Monsoon		Post Monsoon		p-value
	Min.	Max.	Min.	Max.	Min.	Max.	
pH	7.26	7.49	7.17	7.26	7.06	7.64	0.0675
Conductivity (mS/cm)	1332.33	1586.00	1213.00	1272.50	1007.67	1570.33	0.0802
BOD (mg/L)	18.33	36.00	12.50	20.00	7.67	12.33	0.0000**
Nitrate	4.49	14.19	1.67	8.69	2.90	9.28	0.0102*
Fecal Coliform (MPN/100ml)	176.67	263.33	32.00	354.33	35.00	560.00	0.7833
Chloride (mg/L)	145.00	181.00	137.00	150.67	110.67	222.67	0.5242
COD (mg/L)	164.67	241.33	96.00	141.67	57.67	122.33	0.0000**
Hardness (mg/L)	287.33	416.67	266.67	343.33	238.33	353.33	0.2085
Calcium (mg/L)	65.33	91.33	56.00	130.33	58.67	72.00	0.6000
Magnesium (mg/L)	28.80	45.71	30.38	39.49	22.28	45.77	0.3082
Sulphate (mg/L)	45.00	78.33	51.33	76.00	61.67	119.33	0.0038**
Sodium (mg/L)	94.71	147.65	105.67	167.33	90.33	173.00	0.7493

TDS (mg/L)	766.00	924.33	722.00	760.00	607.33	982.67	0.4713
TSS (mg/L)	22.00	103.33	10.00	29.33	12.67	74.33	0.1041
Potassium (mg/L)	16.90	25.19	9.67	17.50	5.00	12.00	0.0000**
Turbidity (NTU)	20.50	53.33	13.00	45.47	7.53	20.67	0.0231*

* The correlation was significant at $p < 0.05$; ** The correlation was significant at $p < 0.01$.

Table 2. Spearman's correlation coefficient values among different water pollutants

Parameters	pH	EC	BOD	Nitrate	Fecal Coliform	Chloride	COD	Hardness	Calcium	Magnesium	Sulphate	Sodium	TDS	TSS	Potassium	Turbidity
pH	1.00															
Conductivity (mS/cm)	0.27	1.00														
BOD (mg/L)	0.31	0.30	1.00													
Nitrate	0.31	0.37	0.23	1.00												
Fecal Coliform (MPN/100ml)	0.19	-0.26	0.36	0.26	1.00											
Chloride (mg/L)	0.09	**0.69**	0.00	0.25	-0.23	1.00										
COD (mg/L)	0.18	0.33	**0.88**	0.35	0.30	0.07	1.00									
Hardness (mg/L)	0.11	**0.62**	0.04	0.25	-0.41	**0.56**	0.21	1.00								
Calcium (mg/L)	0.07	0.34	-0.17	0.09	-0.20	0.35	-0.05	**0.50**	1.00							
Magnesium (mg/L)	0.20	0.45	0.19	0.12	-0.18	0.42	0.21	**0.63**	0.11	1.00						
Sulphate (mg/L)	-0.33	-0.13	**-0.61**	-0.02	-0.26	0.15	-0.43	0.18	0.08	-0.06	1.00					
Sodium (mg/L)	-0.04	**0.58**	0.15	0.36	-0.15	**0.60**	0.17	0.36	0.05	0.20	0.15	1.00				
TDS (mg/L)	0.27	**0.93**	0.20	0.38	-0.29	**0.70**	0.24	**0.65**	0.33	0.47	-0.01	**0.57**	1.00			
TSS (mg/L)	0.40	0.38	0.46	0.42	0.17	0.38	0.45	0.32	0.18	0.22	-0.05	0.33	0.45	1.00		

Potassium (mg/L)	0.25	0.27	**0.75**	0.42	0.40	-0.10	**0.70**	0.05	-0.09	0.09	**-0.52**	0.12	0.17	0.31	1.00	
Turbidity (NTU)	0.23	0.39	**0.54**	0.06	0.03	0.21	0.39	0.04	0.17	0.05	- 0.46	0.25	0.33	0.41	0.38	1.00

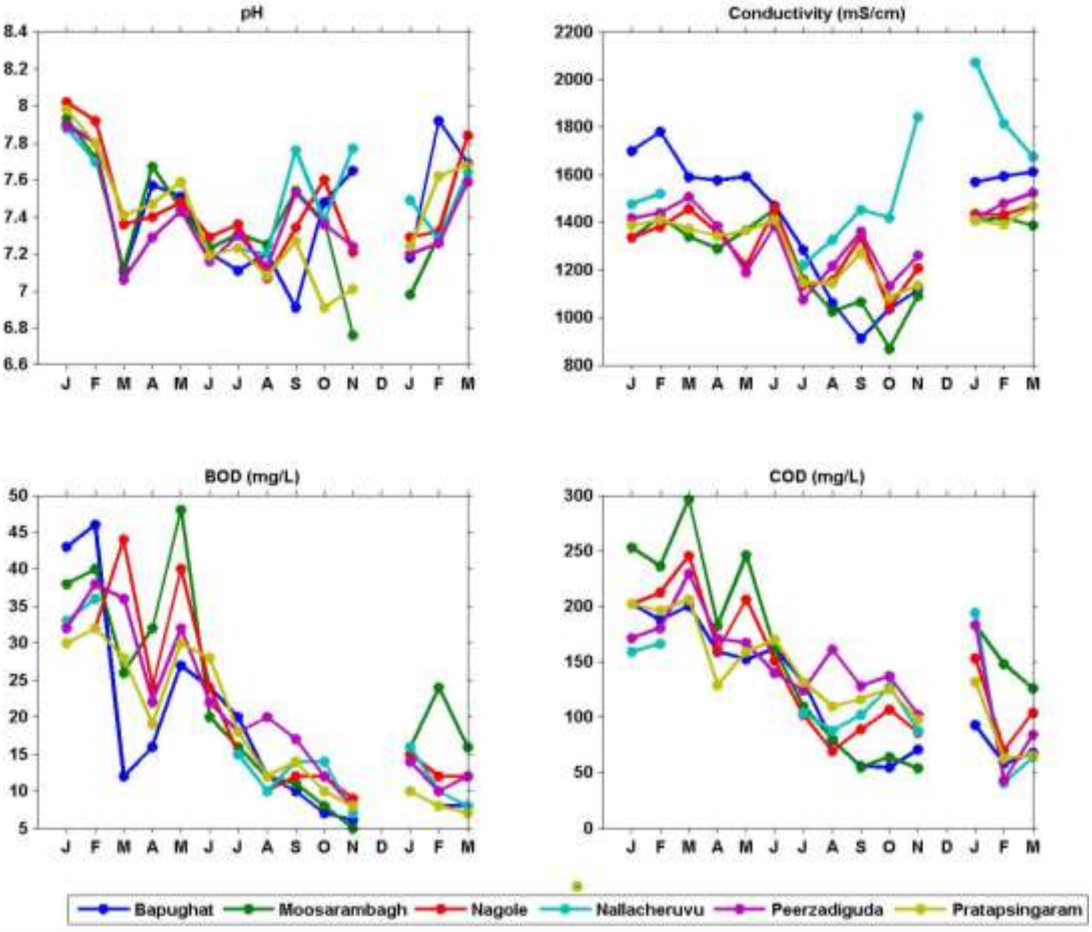

Figure 1: Temporal variations of physicochemical parameters: pH, Conductivity, BOD and COD among different stations

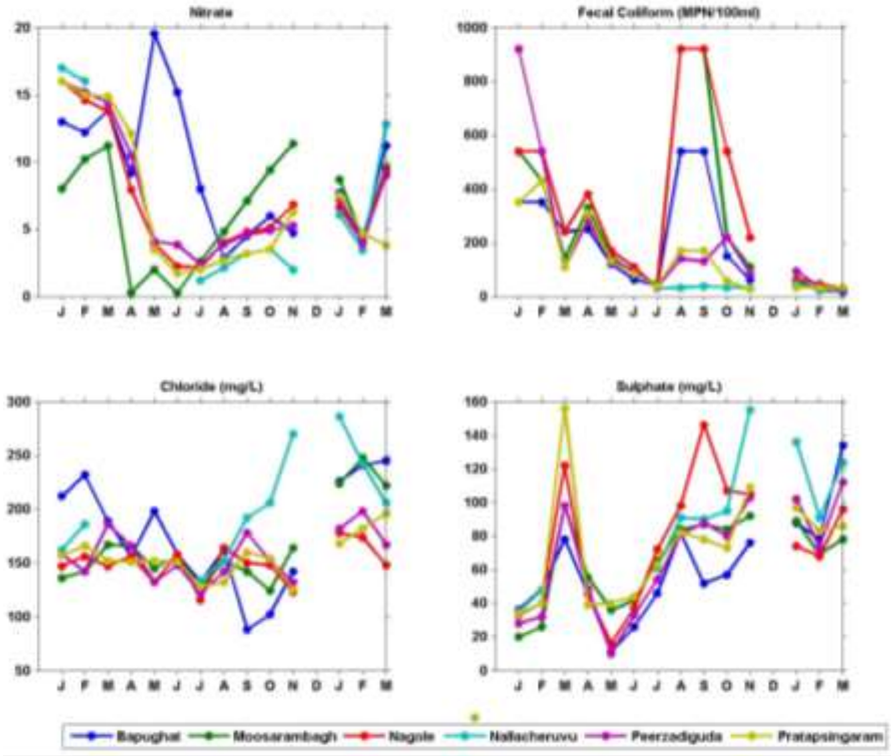

Figure 2: Temporal variations of chemical and microbiological parameters: Nitrate, Fecal Coliform, Chloride and Sulphate among different stations

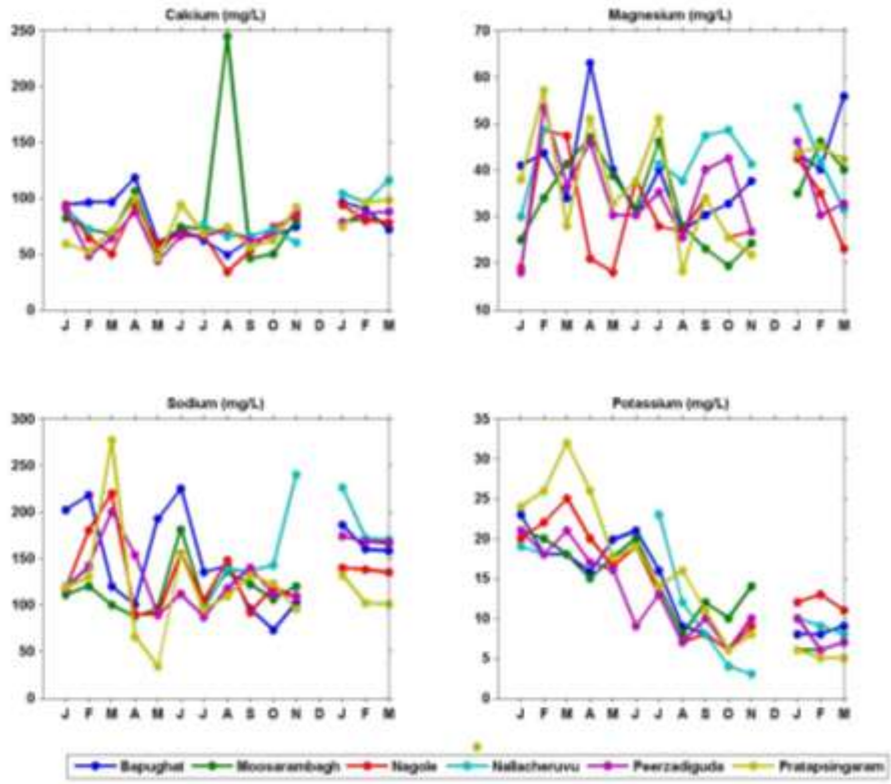

Figure 3: Temporal variations of chemical parameters: Calcium, Magnesium, Sodium and Potassium among different stations

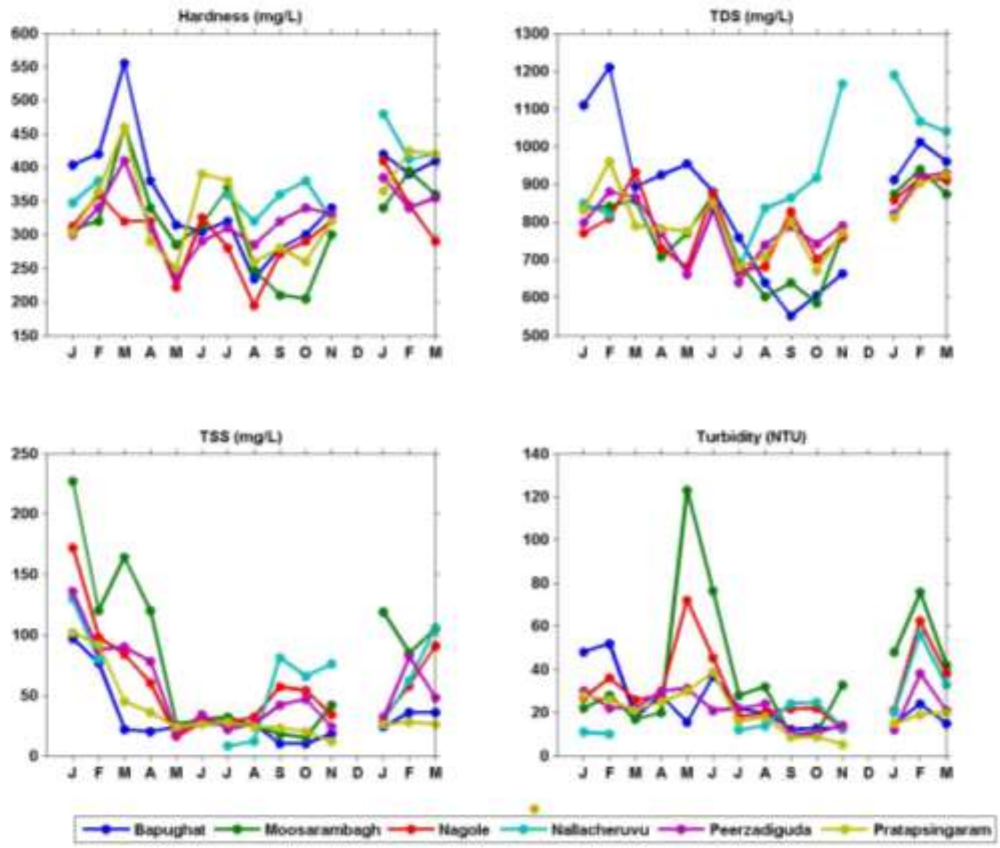

Figure 4: Temporal variations of physicochemical parameters: Hardness, TDS, TSS and Turbidity among different stations

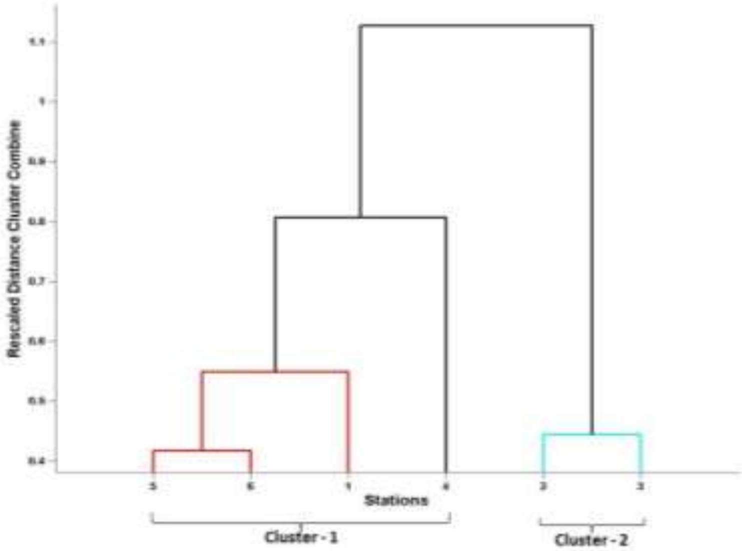

Figure 5: Dendrogram showing clustering of sampling locations based on surface water quality characteristics of the Musi River.