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Research Article

Spatio-temporal Assessment of the Bagmati River Water Using Real-Time Data

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ABSTRACT

Water pollution and tributaries are deteriorating the water quality of the Bagmati river, especially in Kathmandu valley. Mostly, the water quality of the Bagmati river is characterized using traditional methods, therefore, have been unable to identify sources of pollutants. In this study, real-time continuous monitoring and collecting data in a large volume using sophisticated sensors were performed. The diurnal, spatial, daily and temporal variations of physicochemical water quality parameters were presented for an in-depth understanding of the real status of the Bagmati river. The spatial variation of water quality parameters indicated that conductivity was drastically increased (605.41 ± 8.9 to 1145.30 ± 9.32 µS/cm), and the oxidation-reduction potential (ORP) was excessively reduced (28.09 ± 6.88 to -306.75 ± 4.95 mV) after mixing of the tributaries. The high conductivity (>605.41 ± 8.9 µS/cm and negative ORP values (-40.29 ± 32.14 to -306.75 ± 4.95 mV) are an indication of a sewer connection. Daily, diurnal and temporal variations suggested that the Bagmati river is always polluted with a negative ORP value (<-50 mV) in the daytime, and river quality worsens day to day. In conclusion, it is important to control the mixing of effluent into the Bagmati river and its tributaries to revive the river ecosystem and prevent loss of survives.

Keywords: Oxidation-reduction potential; Real-time data; River water pollution; Temporal variation; Tributary

Introduction

The Bagmati river enters the Kathmandu valley at Sundarijal, passes through a densely populated area, and exits at the Chovar. Rapid, unmanaged urbanization generates excessive solid waste and sewage in core city areas within the Kathmandu Valley (MoUD, 2017). Solid waste and effluent from municipal, hospital and industrial outlets are dumped directly into the river (Bhandari et al., 2021; Pant et al., 2021). The river is converting into one of the easily accessible dumping sites for solid wastes and untreated domestic, industrial and agricultural effluents (Kannel et al., 2007; Mishra et al., 2017; Adhikari et al., 2024). It was reported that the Bagmati river is in pristine condition near the Sundarijal, however, it is critically polluted downstream (Regmi, 2013; Mishra et al., 2017). Tributaries drain into the mainstream, serve as important habitats and carry pollutants that contribute unique conditions of the mainstream. The tributaries of the Bagmati river are the most promising factors that modify the water quality downstream (Adhikari et al., 2021). The polluted tributaries, such as Monohara, Dhobikhola, Tukhucha, Bishnumati and Balkhukhola, load contaminants into the Bagmati river between the Shankhamul and Balkhu sites. Due to the mixing of effluent and solid waste, water quality of the Bagmati river downstream is worsening day by day (Mishra et al., 2017; Adhikari, 2020), destroying the river ecosystem and harming the health of people living around it.

The assessment of the Bagmati river and its tributaries reported that conductivity increased and oxidation-reduction potential (ORP) decreased continuously downstream of the river. The dissolved oxygen was almost zero, and the ORP decreased from -100 to -263 mV after mixing of the five polluted tributaries (Adhikari et al., 2021). The water quality index (WQI) was very high, indicating extremely polluted water unfit for domestic as well as agricultural and industrial use (Adhikari et al., 2024). The deterioration of river water quality highlights the necessity of continuous monitoring of water quality to generate awareness among people and carry out the treatment of industrial and domestic waste before its disposal into the river water. Pal et al. (2019) suggested the main river and tributaries are equally polluted, hence, need to take action for sustainability of the aquifer. Previous studies used traditional monitoring with limited data points, therefore, it is not possible to predict the time dependency of river water quality. To pinpoint the sources and time dependency of pollutants, instead of traditional water quality monitoring methods, an advanced monitoring system with fine-scale and real-time data logging was used in this study. A detailed assessment including spatial, diurnal, daily and temporal variations of river water quality in the Bagmati river was analyzed by logging a huge data set. This is a very new approach to monitor/characterize water quality parameters. The time dependency data will provide clear insight of real status of river water and the effects of human activities on the degradation of river water quality. Since it is not possible to collect data of all water quality parameters in real-time and on a fine-scale basis, this study considered that conductivity, dissolved oxygen (DO) and oxidation-reduction potential (ORP) are the most useful parameters indicating sewer pollutants.

Materials and Methods

The daily, diurnal and temporal variations of the Bagmati river water quality was monitored at Shankhamul site. The data on daily variation was collected during the pre-monsoon season in May 2024 on the date of 3, 10, 14, 19, and 21 May. Diurnal and temporal variations were conducted on May 21, 2023, and May 19, 2024. The spatial variation of water quality was determined by collecting data from six different positions along the Bagmati river from Shankhamul to Balkhu sites. Data were continuously collected and logged every 10 second from 6 stations. The observation started from the upstream site of the Manohara tributaries at Shankhamul (B-1), the second data was collected from upstream of Dhobikhola at UN park (B-2), the third was after the confluence of the Dhobikhola (B-3), the fourth from Thapathali after the confluence of Tukuchakhola (B-4), the fifth from Kuleshwor after the confluence of Bishnumati river, and sixth from Balkhu after the confluence of Balkhukhola (B-6) (Figure 1). Real-time fine-scale water quality data were measured using an advanced multi parameter analyzer (HANNA instruments, Hi-9829) (Adhikari et al., 2024). This study mainly focuses on the collection of continuous real-time data to understand the time dependency of river water quality and to point out the source of pollutants. Most commonly, water quality can be characterized by measuring physicochemical parameters for example pH, alkalinity, conductivity, ammonia, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) and heavy metals. The monitoring of all these parameters in real-time basis is tough. Therefore, physicochemical parameters such as temperature, pH, turbidity, total dissolved solids (TDS), oxidation-reduction potential (ORP), dissolved oxygen (DO) and conductivity were measured and logged on a real-time basis. Based on the previous studies (Adhikari et al. 2021, Pant et al. 2021), it is considered that the conductivity and total dissolved solids are useful to predict the level of contaminants, dissolved oxygen, and oxidation-reduction potential are useful to predict the sewer pollution.

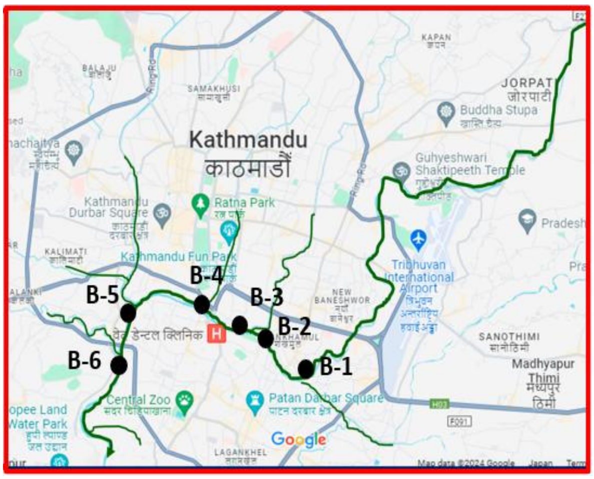

Figure 1: Sampling sites in the Bagmati river, Kathmandu, Nepal.

Results and Discussion

Spatial variation of water quality parameters

The physicochemical characteristics of water were determined along the Bagmati river by collecting data from six different sites. The sampling sites were chosen to determine the source of pollutants and the effect of tributaries on the main river. Data were collected same time but on different days to minimize the effect of time on the analysis. More than 150 data sets were collected from each station. Data recorded from 11:50 to 12:15 in May 2023. The observed water quality parameters are shown in Figure 2. The river water temperature varied from 23.87 ± 0.34 to 28.31 ± 0.19 °C may be due to variation of air temperature on different days (Figure 2a). The observed turbidity was also low, 110.48 ± 2.32 FNU at the B-1 and higher than 167 FNU at other observation sites (Figure 2b). The increase of turbidity in downstream was also reported (Pal et al., 2019). It may be due to the mixing of soil or effluent in the river water (Costa et al., 2015).

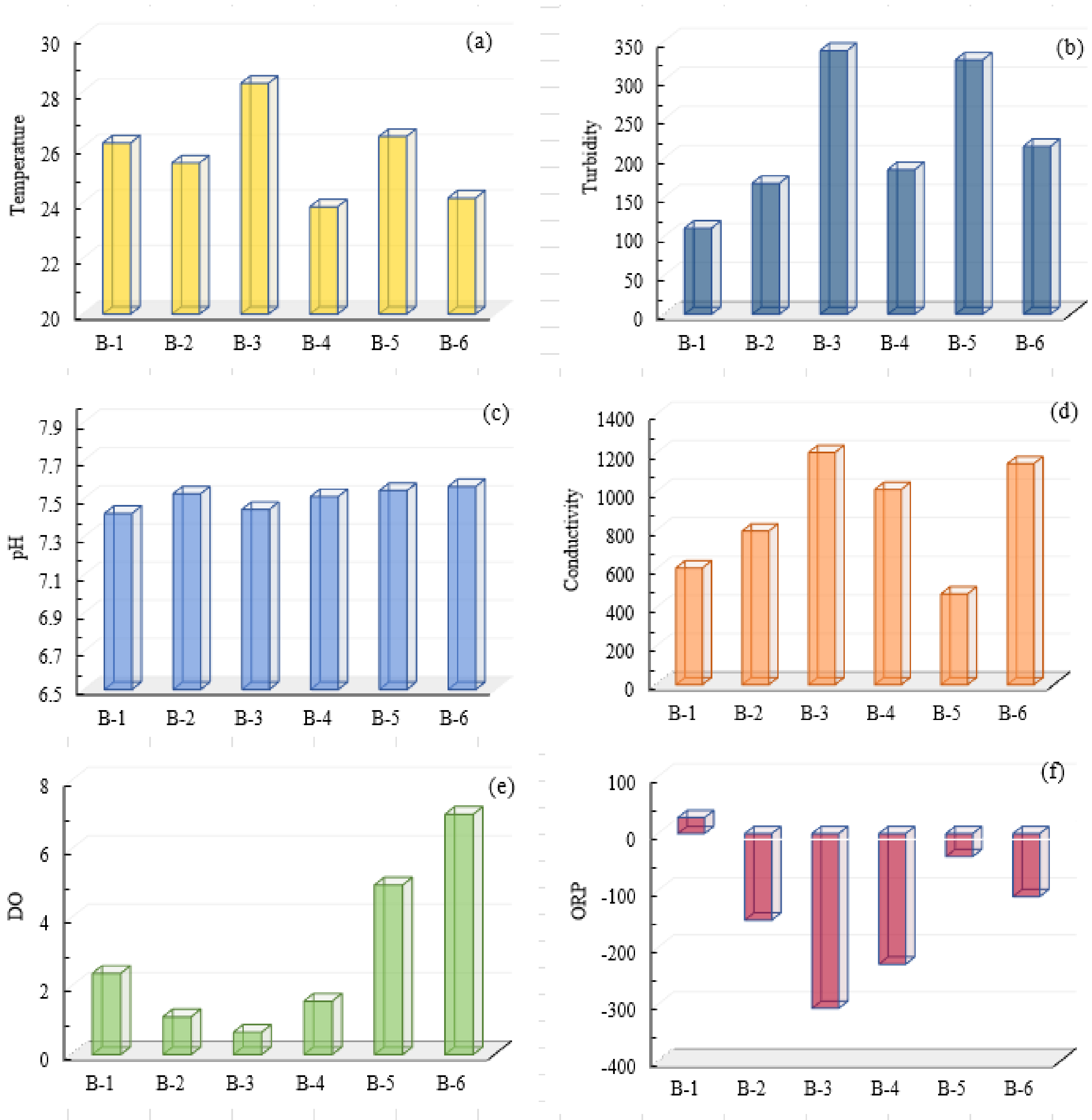

Figure 2: Spatial variation of water quality parameters (a) Temperature (°C), (b) Turbidity (FNU), (c) pH, (d) Conductivity (µS/cm), (e) DO (ppm), and (f) ORP (mV).

The pH of river water was comparatively low (7.42±01) upstream and increased slowly to 7.56 ± 0.01 near the end of the observation at the Bagmati river (Figure 2c). Similar results were reported by Adhikari et al. (2021). Water with pH less than 6.5 could be soft while above 8.5 could be hard and corrosive (Modoi et al., 2014;

WHO, 1999). The slightly alkaline pH of river water may be due mixing of ammonical compounds from domestic and agricultural effluent (Aggarwal & Arora 2012), and/or microbial decomposition of organic matters (Sundararajan et al., 2018). The conductive ions present in the water are related to conductivity. The comparatively low conductivity (470 ± 7.46 µS/cm) was observed at B-5, the conductivity was more than two times at B-3 (1203.24 ± 1.30), B-4 (1012.24 ± 3.60) and B-6 (1145.30 ± 9.32). It was increased almost continuously downstream (Figure 2d). Another vital parameter of the water quality is the dissolved oxygen (DO). The concentration of DO was less than 3 ppm B-1 to B-4, and it was high at B-5 and B-6 (Figure 2e). The oxidation-reduction potential (ORP) is useful to measure the water disinfection potential in wastewater treatment (Suslow et al., 2004; Goncharuk et al. 2010). The reducing agent decreases the ORP value, and the oxidizing agent increases the ORP value. The observed ORP of river water was positive and was 28.09±6.88 upstream at B-1, it was less than -50 mV at other observation sites, and it varied from -40.29 ± 32.14 to -306.75 ± 4.95 (Figure 2f). The 50 to 250 mV ORP is suitable for the nitrification and organic compounds degradation (Suslow et al., 2004; Goncharuk et al., 2010).

The denitrification occurs from +50 to -50 mV and biological phosphorus and sulfide release between -50 and -250 mV of ORP. The positive ORP value at B-1 indicates the possibility of nitrification of river water, however low ORP (< -50 mV) downstream suggests that the river water is extremely polluted with reducing substances from wastewater. The water with low ORP produces biological phosphorus and sulfide, generating a stinky smell that is toxic and responsible for an unhealthy environment around it and for aquatic animals (Suslow et al., 2004; Goncharuk et al., 2010). The low ORP value but high DO concentration at B-5 and B-6 may be due to the dissolution of atmospheric oxygen at the dam at Kuleshwor bridge and at Balkhukhola.

Diurnal variation of water quality parameters

Real-time continuous data on water quality parameters were collected in the pre-monsoon period on 21 May 2023 and 19 May 2024. Diurnal variations of water quality parameters were plotted in Figure 3. The temperature shows similar diurnal variations on both days, increasing slowly with time and decreasing slowly after 14:00. The maximum temperature was observed at 14:00 on both observation days (Figure 3a). The diurnal variations of conductivity on 19 and 21 May were slightly different. It was nearly double on 19 May 2024 than on 21 May 2023. The highest recorded conductivity was about 628 µS/cm, and the lowest value was about 526 µS/cm on May 21. It was 1123 and 780 µS/cm respectively on May 19 (Figure 3b). The pH was slightly alkaline and variation was less pronounced on 21 May (7.43 to 7.56), but it was neutral to slightly acidic and slowly decreased at afternoon on 19 May (7.1 to 6.8) (Figure 3c). Total dissolved solids were about 263 ppm initially and slowly increased with time and reached 360 ppm at evening on 21 May. It was almost two times high on 19 May 2024. The observed TDS was as high as 560 ppm on 19 May 2024 (Figure 3d). The maximum TDS of 612 ppm downstream was reported in previous study (Pal et al., 2019). The previous research concluded that anthropogenic wastes, for example, municipal and industrial, are responsible to increase conductivity and TDS downstream. Dissolved oxygen (DO) in water increases with atmospheric oxygen and photosynthesis, but it is decreased by biochemical and chemical phenomena occurring in water (Athokpam et al., 2014; Aniyikaiye et al., 2019). The dissolved oxygen was high (>6ppm) initially and decreased linearly with time up to 1 ppm at noon, and increased slowly and reached 2 ppm in the evening on 21 May (Figure 3e). It was very low, < 1 ppm, on 19 May in whole observed day though a slightly higher value was observed initially.

A very low concentration of DO indicates that it is almost impossible for aquatic animals to survive on it. The ORP value was initially positive and linearly decreased to negative on 21 May, however, it was always negative on May 19. The decreasing pattern of ORP value was almost similar on both days, though values were different (Figure 3f). The diurnal variation patterns of DO and ORP on 21 May were similar to those of DO and ORP reported by Adhikari et al. (2019). Due to the very low concentrations, the variation of DO on 19 May was not pronounced, but ORP showed a similar trend. All the results suggested that the river water at the Shankhamul region is influenced by local pollutants from human activities. All measured water quality parameters indicated that the river water consists of more contaminants in the year 2024 than in 2023. The comparatively high concentration of conductivity, low concentration of DO, and low values of pH and ORP reveal that the Bagmati river water quality is degrading continuously at an alarming rate.

It suggests the necessity of the implementation of strict rules and regulations to control anthropogenic activities toward river water pollution for the prevention of further degradation of the holy river.

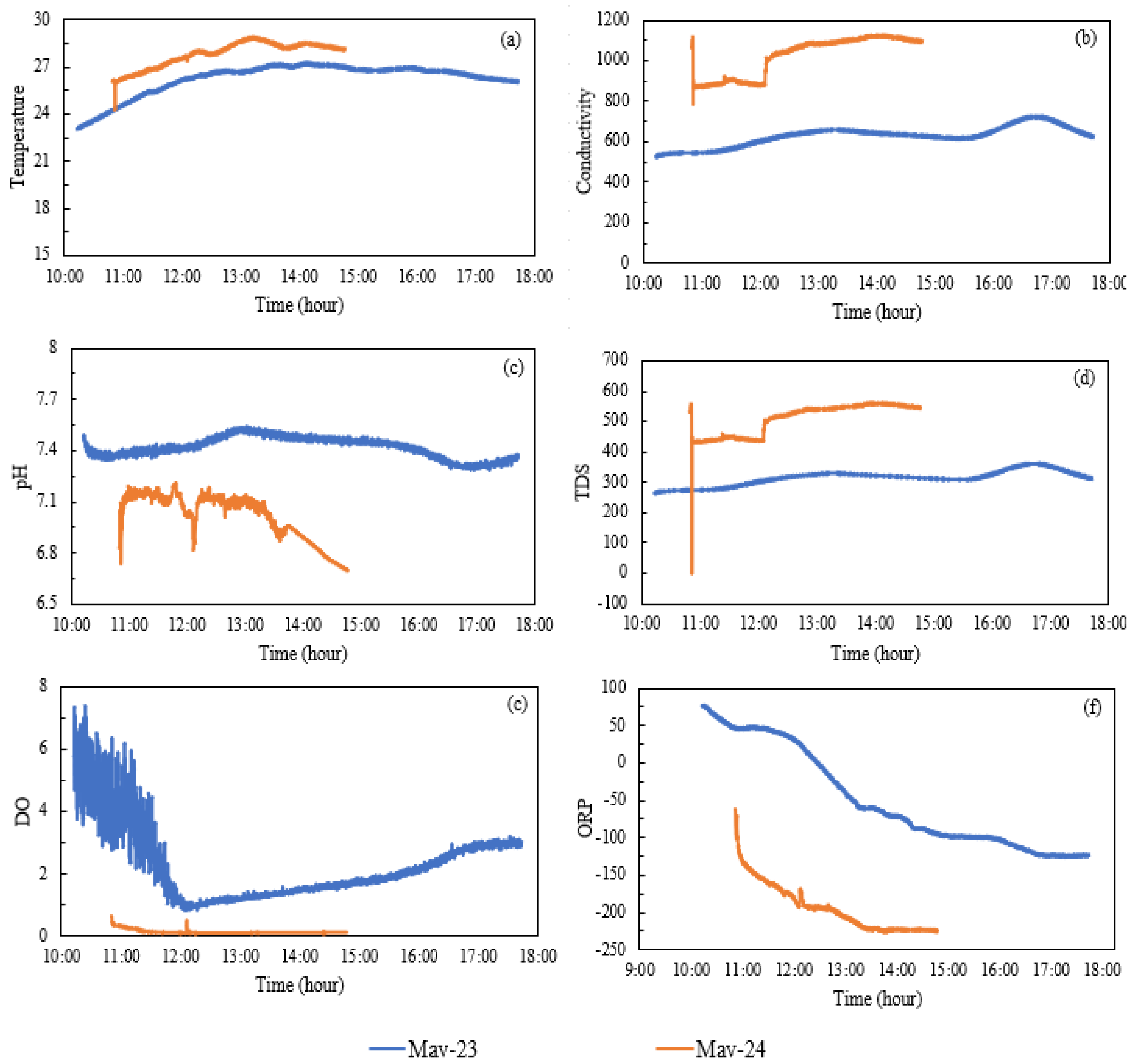

Figure 3: Diurnal variations of water quality parameters (a) Temperature (°C), (b)Conductivity (µS/cm), (c) pH, (d) TDS (ppm), (e) DO (ppm), and (f) ORP (mV) measured on May 21, 2023, and May 19, 2024.

Daily variation of water quality parameters

Daily variations of water quality parameters of the Bagmati river were observed in pre-monsoon (May 2024). The observed temperature, ORP, pH, DO, conductivity and turbidity were plotted in Figure 4. The water temperature ranged from 24 to 29 °C during the pre-monsoon period (Figure 4a). The turbidity was as high as 287 FNU on Day 2, but less than 10 on other days (Figure 4b). The pH was comparatively high on Day 1 and slowly decreased afterward (Figure 4c). The conductivity was as high as 1020 µS/cm on Day 1 and was lowest on Day 2 (413 µS/cm), higher than >850 µS/cm on the other days (Figure 4d).

The dissolved oxygen was less than 0.5 ppm on all days except on Day 2 (2.47 ppm) (Figure 6e). The ORP value was always negative (< -100 mV) except on Day 2 (39.5 mV) (Figure 4f). The observed water quality of Day 2 was different than that of other days. The conductivity was low, dissolved oxygen was high, and the ORP value was positive on this day, although all data was collected on same time. All the parameters indicated that the river water was less polluted on this day. It was observed from the recorded weather system that on Day 2 (10 May), the heavy rainfall occurred from 2:15 to 3:15, and light rain occurred at 5:15. Therefore, it is considered that the heavy rainfall reduced the pollutants and enhanced dissolved oxygen, which enhanced the ORP value on Day 2 (10 May 2024). The dissolved oxygen and ORP values indicated that the water quality of the Bagmati river was always heavily polluted. The very low ORP indicated that the water consists of organic pollutants that consume dissolved oxygen excessively.

The negative ORP value (< -50 mV) suggested that there were excessive amounts of organic contaminants from the sewer which excessively reduced dissolved oxygen. The results suggested that the inflow of domestic effluent continuously loads pollutants in the Shankhamul region. This is the reason why the dissolved oxygen remains low on all days. The analytical results suggest that the Bagmati river water is highly influenced by anthropogenic activities, which is reduced to some extent by heavy rainfall.

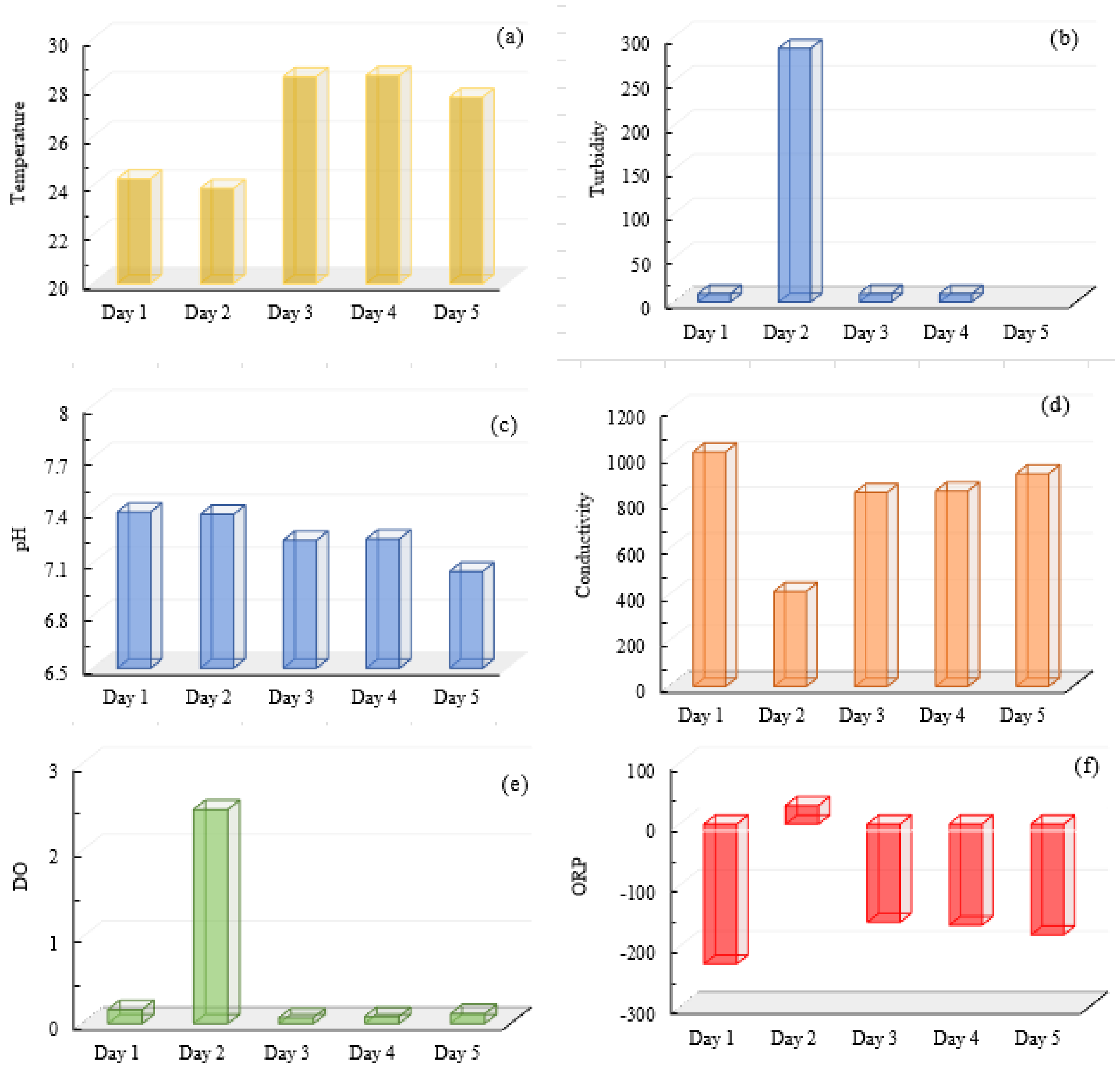

Figure 4: Daily variation of water quality parameters (a) Temperature (ºC), (b) Turbidity (FNU), (c) pH, (d) Conductivity (µS/cm), (e) DO (ppm), and (f) ORP (mV) in May 2024 at the Shankhamul site.

Conclusion

This study collected fine-scale real-time data of different water quality parameters along the Bagmati river. The diurnal, spatial, daily and temporal variations of water quality parameters were analyzed. The analytical results suggested that river water was radically changed after mixing of the tributaries. The measured conductivity was 605.41 ± 8.9 µS/cm at Shankhamul before confluence of tributaries, after mixing of the Dhobikhola tributary, it increased to 1203.24 ± 1.3 µS/cm, and it was 1145 µS/cm at the end of the observation at Balkhu. Further, oxygen reduction potential (ORP) was excessively reduced after mixing of tributaries. it was positive and comparatively high (28.09 ± 6.88 mV) at Shankhamul but reduced to a negative value as low as -306 mV after mixing of Dhobikhola, indicating extremely polluted conditions with large amounts of reducing pollutants. The river water quality was more degraded temporally i.e., worse in the year 2024 than in 2023. The diurnal variation suggested that the daytime increment of contaminants is due to human activities. The excessively negative ORP suggested the polluted river water was responsible for the stinky smell. The daily variation of water quality parameters showed that the monsoon rain reduced pollutants to some extent; however, effluents quickly worsened the quality of the Bagmati River. The contaminants consume almost all the oxygen; hence, living organisms cannot get enough oxygen to survive in it. In addition, it spreads a hazardous fouling smell along the bank of the river. This study investigates the temporal, daily, diurnal, and spatial conditions of the Bagmati River water, useful for the researcher and policy maker to understand the ecological condition of the holy river. Further continuous study is necessary to improve the river water quality by generating awareness and taking action on sewer management.

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References

Adhikari, M. P, Rawal, N. B., & Adhikari, N. B. (2021). Real-time fine-scale measurement of water quality parameters along the Bagmati River in the Kathmandu Valley. *Nature Environment and Pollution Technology, 20*(3), 1047–1057.

Adhikari, M. P. (2020). Physicochemical characterization of city supply, underground and river water of Kathmandu, Nepal. *International Research Journal of Environmental Sciences, 9*(3), 35-43.

Adhikari, M. P., Rawal, N. B., Pradhananga, A. R., & Adhikari, N. B. (2024). Assessment of water quality index and role of tributaries on the degradation of Bagmati River water. *Journal of Water and Environment Technology, 22*(6), 255-270.

Aggarwal R. & Arora. S. (2012). A study of water quality Kaushalya River in the submountaneous Shivalik region. *International Journal of Scientific and Technology Research*, *1*(8), 52-68.

Aniyikaiye, T.E., Oluseyi, T., Odiyo J. O., & Edokpayi J. N. (2019). Physico-chemical analysis of wastewater discharge from selected paint industries in Lagos, Nigeria. *International Journal of Environmental Research and Public Health, 16*(7),1235.

Athokpam, D., Kumawat, D. M., & Gupta, A. (2014). Spatio-temporal variation in certain physico-chemical parameters of water from Imphal River, Manipur. *Journal of Scientific Research and Reports*, *3*(17), 2245-2261.

Bhandari, P., Banjara, M. R., Singh, A., Kandel, S., Rawal, D. S., & Pant, B. R. (2021). Water quality status of groundwater and municipal water supply (tap water) from Bagmati river basin in Kathmandu valley, Nepal. *Journal of Water, Sanitation and Hygiene for Development*, *11*(1), 102-111.

Costa, J. S., Braga, F. S., Almeida, S. S. M.S., Ramos, R. S., Brito, D. C., Cunha, A. C. & Santos, C. B. R. (2015). Physicochemical characterization of water quality-Lagoa dos Indios in Bacapa, Brazil. *American Chemical Science Journal, 5*(2), 122-134.

Goncharuk, V. V., Bagrii, V. A., Mel'nik, L. A., Chebotareva R. D. & Bashtan S. Yu (2010). The use of redox potential in water treatment processes. *Journal of Water Chemistry and Technology*, 32(1), 1-9, 2010.

Kannel, P. R., Lee, S., Kanel, S. R., Khan S. P., & Lee, Y. S. (2007). Spatial-temporal variation and comparative assessment of water quality of urban river system: a case study of the river Bagmati (Nepal). *Environmental Monitoring and Assessment, 129*, 433-459.

Mishra, B. K., Regmi, R. K., Masago, Y., Fukushi, K., Kumar P. & C. Sarawat (2017). Assessment of Bagmati River pollution in Kathmandu Valley: Scenario-based modelling and analysis for sustainable urban development. *Sustainability of Water Quality and Ecology, 9*, 67-77.

Modoi, O. C., Roba, C., Torok Z. & Ozunu, A. (2014). Environmental risks due to heavy metal pollution of water resulted from mining wastes in NW Romania, *Environmental Engineering and Management Journal*, *13*(9), 2325-2336.

MoUD. (2017). National Urban Development Strategy-Part B. Government of Nepal, Ministry of Urban Development. [Accessed: 30-Jan-2025].

Pal, K. B., Pant, R. R., Rimal, B., & Mishra, A. D. (2019). Comparative assessment of water quality in the Bagmati River basin, Nepal. *Zoo-Journal*, *5*, 68-78.

Pant, R. R., Bishwakarma, K., Qaiser, F. U. R., Pathak, L., Jayaswal, G., Sapkota, B., ... & Maskey, R. (2021). Imprints of COVID-19 lockdown on the surface water quality of Bagmati river basin, Nepal. *Journal of Environmental Management*, *289*, 112522.

Regmi, S. (2013). Wastewater treatment in Khatmandu: management, treatment and alternative. Bachelor's Thesis. Mikkeli University of Applied Sci. Finland.

Sundararajan, S., Kamalakannan, B., Karthikeyan, R., Khadangaand M. K. & Jena B. K. (2018). Diurnal variation and water quality parameters of three different ecosystems in Gulf of Mannar, Southeast Coast of India, *Journal of Marine Science: Research and Development, 8*(3), 1-6, 2018

Suslow. T. V., (2004) Oxidation -Reduction potential for water disinfection monitoring, control and documentation, *UC Agriculture and Natural Resources*, 1-5.

WHO. (1999). *International Standard for drinking water*, *5*, 3-6.