Advances in Environmental Technology 10(1) 2024, 1-11

Iranian Reasearch Organization for Science and Technology (IROST)

Advances in Environmental Technology

Journal home page: https://aet.irost.ir/

Study on the performance of wetlands and impact on water quality in a densely populated urban area in Amanaka, Raipur, Chhattisgarh, India

Arvind Kumar Swarnakar*, **Samir Bajpai, Ishtiyaq Ahmad**

Department of Civil Engineering, National Institute of Technology Raipur, P.O. Box 492010, Chhattisgarh, India

ARTICLE INFO

Document Type:
Research Paper

Article history:
Received 20 August 2023
Received in revised form 21 November 2023
Accepted 26 November 2023

Keywords:
Wetlands
Wastewater
Ponds
Groundwater
Borewell
Water quality

ABSTRACT

The quality of groundwater (GW) depends on its surrounding environment, such as population, drains, ponds, and industries. This study evaluated the improvement of wastewater (WW) quality due to the wetland and ponds in the Amanaka, Raipur region of Chhattisgarh, India, and their impact on GW. Water samples were taken at four different locations to measure physicochemical parameters: pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), nitrate nitrogen (NN), and total phosphorus (TP). The removal efficiency (RE) obtained through the wetland was 50.0% for BOD_5, 87.9% for COD, 71.4% for TKN, 87.2% for NN, and 56.5% for TP from the influent. The obtained RE from the wetland to the pond was 72.6% for BOD_5, 40.0% for COD, and 89.6% for TP during the pre-monsoon. According to the findings, GW quality was good, even though ponds, wetlands, and some small-scale industries surround it. The government should also monitor landfills, home garbage, and agricultural activities for sustained GW quality. All borewell water is drinkable.

1. Introduction

Around the world, 663 million people, mostly in developing countries, rely on contaminated or dangerous water for drinking and cooking [1]. Over-exploitation of GW by the introduction of saline water, diminishing stream flow, and the drying up of wetlands and springs has lowered its quality. In India, excessive GW resource consumption has led to decreased water levels, a lack of water supplies, and poor GW quality [2]. Freshwater issues plague many nations worldwide, and India is no exception. As per the Central Pollution Control Board's current information, India produces about 72,368 MLD of municipal wastewater nationwide, of which about 40,527 MLD is discharged directly into surface water bodies [1]. It has resulted in a decline in aquatic life and surface water quality, a hazard to human health and the environment, and the emergence of

*Corresponding author
E-mail: akswarnakar@nitrr.ac.in
DOI: 10.22104/AET.2023.6442.1760

serious waterborne illnesses. Environmental conditions and microphytes affect the solids (suspended and dissolved), bacteria, organic matter (BOD_5 and COD), nutrients, and heavy metals from WW [3-6]. In this case study, nature-based treatment processes are most effective. Soil adsorption and plant uptake, chemical precipitation, anaerobic or aerobic microbial growth, decomposition activity, and sunlight are some examples of natural removal mechanisms [3,6]. In India, Raipur Chhattisgarh is a city of ponds. Raipur is the capital of Chhattisgarh. In 2023, Raipur city is expected to have 1,392,000 residents, and 12,383 sq-km is the total area of the district https://www.indiagrowing.com/Chhattisgarh/Raipur_District). Water features are a crucial part of a smart city. The value of green spaces, wetlands, ponds, various water bodies, and uncluttered regions is well acknowledged, as Raipur has developed into a megacity over the past few decades. The combination of natural wetlands and ponds makes for good groundwater quality [7]. Much study has been done on the various ponds in the Raipur area [8-10]. Wetland water resources are heavily used for irrigation, fisheries, industrial water, agricultural cultivation, and other purposes [11,19]. Environmental impact assessment is crucial for recognizing, anticipating, and reducing the many environmental effects. Wastewater comprises organic materials from human excrement, food waste, kitchen scraps, soaps, and detergents. Wetlands can remove ammonia, phosphorus, and nitrogen from WW [12-15]. However, to the best of our knowledge, research has yet to be done on the impact of long-term functioning wetlands and ponds on GW. The study will offer a thorough understanding of the physicochemical properties and associated effects in the groundwater of ponds and wetland areas.

2. Study area

This permanent wetland was created when residential and sewage effluent from the townships of Amanaka, Kota, and Raipur City was pooled in one location. The study area's rear side is on the Great Eastern Road– Howrah major rail route, with the total population of Raipur reported to be 40,63,872 [16]. Geographically, it is located between the latitudes of 12°15′N and 12°35′N and the longitudes of 37°10′E and 37°25′E (Figure 1).

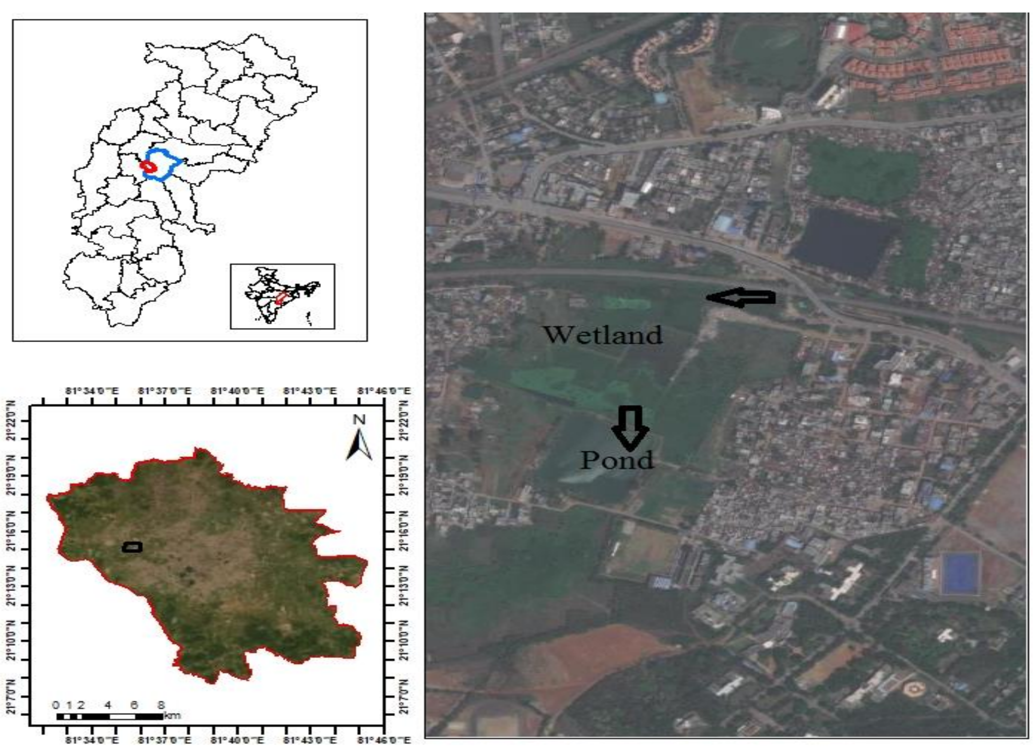

Fig. 1. Location plan of study area.

The wetland's unique hydrochemical and geochemical characteristics, which are brought about by the sewage it receives, make it an important bird area (IBA) [17,18]. Nonetheless, this wetland is maintained by an abundance of aquatic vegetation: Typha latifolia, an ever-dominant marsh species; Eichhornia crassipes, a free-floating species; and Canna indica and Ipomoea aquatica roots, submerged floating species. Figure 2 shows the level of water between the wetland and the pond. A huge variety of permanent and migratory species, including egrets, moorhens, pond herons, great egrets, common cormorants, pheasant-tailed and bronze-winged jacana, etc., call the marsh home. The study area was divided into two watersheds, the wetland and the pond.

Fig. 2. Site view of watersheds (wetland and pond).

2.1. Source of pollution

The study area is densely populated and uses septic tanks and sock pits for sewage management. Some narrow roads exist, and no garbage or sewage management exits, although waste collection (door-to-door) arrangements are available. The major source of sewage is greywater, and sewage WW comes from houses in the study area. One main drain from the city is available in the study area, and WW is available all the time in the study area (Figure 2).

3. Materials and methods

3.1. Sampling and Sampling Locations

As per Figure 3, ten water samples (surface water) were collected into 1000 ml sample collection bottles (HDPE) from ten different locations of influents (In1, In 2), Pond (P1, P2, P3), Wetland (W1, W2) and borewell (B1, B2, B3) during the pre-monsoon season in June 2021. All post-monsoon samples were collected in July 2023. The bottles were scrubbed and sanitized with a detergent solution before being rinsed with deionized water, dried, and used to collect the water samples. Following sample collection, the bottles were immediately closed and clearly labeled [19]. The samples were then immediately taken to the lab to be measured and analyzed for water quality parameters. Figure 3 shows the direction of flow and the location of the sampling points.

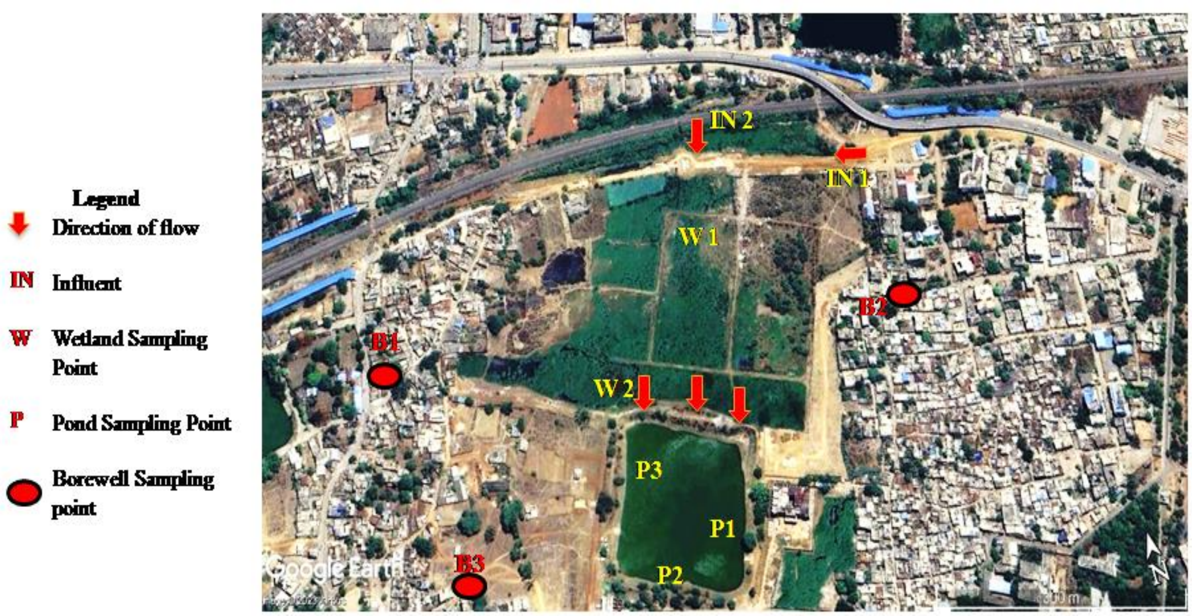

Fig. 3. Direction of the flow and location of the sample.

3.2. Sample analysis, instrumental techniques, and data collection

All water analysis was done in the Environmental Engineering Lab, Department of Civil Engineering, NIT Raipur. After taking the samples to the lab, the condition and quality of the water across the Amanaka wetland and pond system were examined. The physical and chemical characteristics of the lake water were examined in order to achieve that. The samples were collected using clean polythene bottles (1 L) and analyzed in accordance with the American Public Health Association's sampling protocol [20]. A EUTECH pH/EC/TDS/Temperature meter was used to measure the total dissolved solids (TDS) and pH, as opposed to the EUTECH multi-parameters used to test the electrical conductivity (EC), temperature, and DO in the field. Titrimetric analysis was used to determine alkalinity, chloride, and hardness.

The assessment of the percent removal efficiency (RE, %) was done using the equation below:

$$RE, \% = \left(\frac{(Cin-Cout)}{Cin}\right) * 100 \quad (1)$$

where Cin is the Influent concentration (mg/L) and Cout is the Effluent concentration (mg/L).

4. Results and discussion

Figure 3 shows the current state of the physio-chemical characteristics of the ten water samples used in this investigation. pH is one of the most important quality criteria for field study. The sample pH values were in the range of 6.9 and 7.9 (Table 1 and Figure 4A). The investigation found that sample P2 had the highest pH value, whereas sample In1 had the lowest pH value, showing that the water quality of In1 was slightly acidic.

Table 1. Level of different water quality parameters of wetland, pond, and borewell (n = 5) in the pre-monsoon.

Parameters	Influents		Wetland		Pond			Borewell		
	In1	In2	W1	W2	P1	P2	P3	B1	B2	B3
pH	6.9	7.3	7.2	7.4	7.8	7.9	7.7	7.1	7.2	7.1
EC (μS/cm)	1247	1148	1063	1069	610	623	632	1011	981	992
TDS (mg/L)	732	789	683	687	410	412	406	740	732	721
Alkalinity (mg/L as $CaCO_3$)	310	318	270	278	261	267	272	290	288	272
Chloride (mg/L as Cl^-)	144.0	141.2	79.2	78.1	47.3	49.5	52.9	21.6	28.5	36.2
Total hardness (mg/L as $CaCO_3$)	326.1	342.3	274	276	148	155	162	210	201	205
Ca^{2+} hardness (mg/L as $CaCO_3$)	152.2	149.7	61.0	64.0	52.0	51.0	51.0	72.0	75.0	81.0
DO (mg/L)	3.3	3.5	4.8	5.1	5.6	5.5	5.7	6.1	6.2	5.8
BOD_5 (mg/L)	38.0	42.5	21.0	19.2	6.2	6.1	7.2	BDL	BDL	BDL
COD (mg/L)	212.0	202.0	28.0	22.0	12.0	15.0	18.0	BDL	BDL	BDL
TKN (mg/L)	58.8	55.5	16.8	15.8	21.0	14.0	18.2	BDL	BDL	BDL
Nitrate Nitrogen (mg/L)	67.3	65.2	8.7	8.6	33.9	30.2	32.1	0.6	0.8	0.2
Total Phosphorus (mg/L)	47.3	45.7	15.3	25.1	2.2	1.9	2.1	BDL	BDL	BDL

BDL- Below detection limits

According to the study, the site at In1 had a lower pH value than all the other samples due to the presence of effluent from the nearby automobile and the battery industry. According to Islam et al., the water at Hatirjheel Lake had a mean pH value of 7.2 [21]. The ability of water to conduct electrical current was determined by a property known as EC [8]. The EC varied from 610 to 1247 μS/cm (Table 1 and Figure 4 B). The investigation found that samples In1 and In2 (inlet) had the greatest EC values, whereas the sample of the pond had the lowest. The inlet EC concentration was higher than what was allowed (WHO 2003). The quantity of solids in a water sample is known as TDS [22]. The inlet's higher TDS concentration was 789 mg/L (Table 1 and Figure 4 C). The RE of TDS through the

wetland was 9.9 % (Table 2). The analysis discovered that sample 1 (In2) had the highest TDS value, and sample P1 had the lowest (Figure 4 C).
Some households dispose of domestic waste and WW very close to the study area. The TDS value was higher than that of all other sampling sites. 1000 mg/L was the accepted upper limit for TDS (ECR 1997). The determination of alkalinity, hardness, and chloride was done using the titrimetric approach. The samples total alkalinity concentration fluctuated between 318 mg/L to 261 mg/L. Similar results are shown in the study [23]. Samples 1 and 2 (In1 and In2) had the highest levels of alkalinity, whereas the pond water sample had the lowest levels (Figure 4 E). Minerals like calcium and magnesium caused the water to be hard. Minerals are dissolved in soft water in smaller amounts than hard water, which is a major difference. The study area total hardness ranged between 342.3 and 148 mg/L (Table 1 and Figure 5 A). Sample In2 had the highest total hardness, and Sample P1 had the lowest (Figure 5 B). The Total Hardness was often present in concentrations of 200–500 mg/L (ECR 1997; WHO 2003). The Ca^{2+} hardness of the water samples was assessed (Figure 5 B). The southwest monsoon starts at the end of June and continues until the beginning of October. Raipur receives an average of 1300 mm of rainfall during the rainy season (https://www.accuweather.com). Due to rain, all the physicochemical parameters get diluted, which reduces their concentration (Table 3). The effect of a lack of concentration due to rain can be seen in Tables 2 and 3.

Table 2. Percentage removal efficiency (RE) through wetland and pond during pre-monsoon.

Parameters	Influents Average	Wetland Average	RE, %	Pond Average	RE, %
TDS (mg/L)	760.5	685.0	9.9	409.3	40.2
Chloride (mg/L as Cl^-)	142.6	78.6	44.9	49.9	36.5
Total hardness (mg/L as $CaCO_3$)	334.2	275.0	17.7	155.0	43.6
BOD_5 (mg/L)	40.2	20.1	50.0	6.5	72.6
COD (mg/L)	207.0	25.0	87.9	15.0	40.0
TKN (mg/L)	57.1	16.3	71.4	17.7	-8.6
Nitrate Nitrogen (mg/L)	66.2	8.5	87.2	32.1	-277.6
Total Phosphorus (mg/L)	46.5	20.2	56.5	2.1	89.6

Table 3. Physicochemical parameters of influent in the post-monsoon season (n = 3).

S. No.	pH	TDS, mg/L	Chloride (mg/L as Cl^-)	Total hardness (mg/L as $CaCO_3$)	BOD_5 (mg/L)	COD, (mg/L)	TKN, (mg/L)	TP, (mg/L)	DO, (mg/L)
Influents	7.6	315	112.8	219.3	19.2	58.6	22.1	35.3	4.4
Wetland	7.3	289	51.5	172.8	12.3	12.2	10.5	15.2	6.2
Pond	7.1	252	38.2	111.5	7.4	9.5	8.7	1.8	6.5

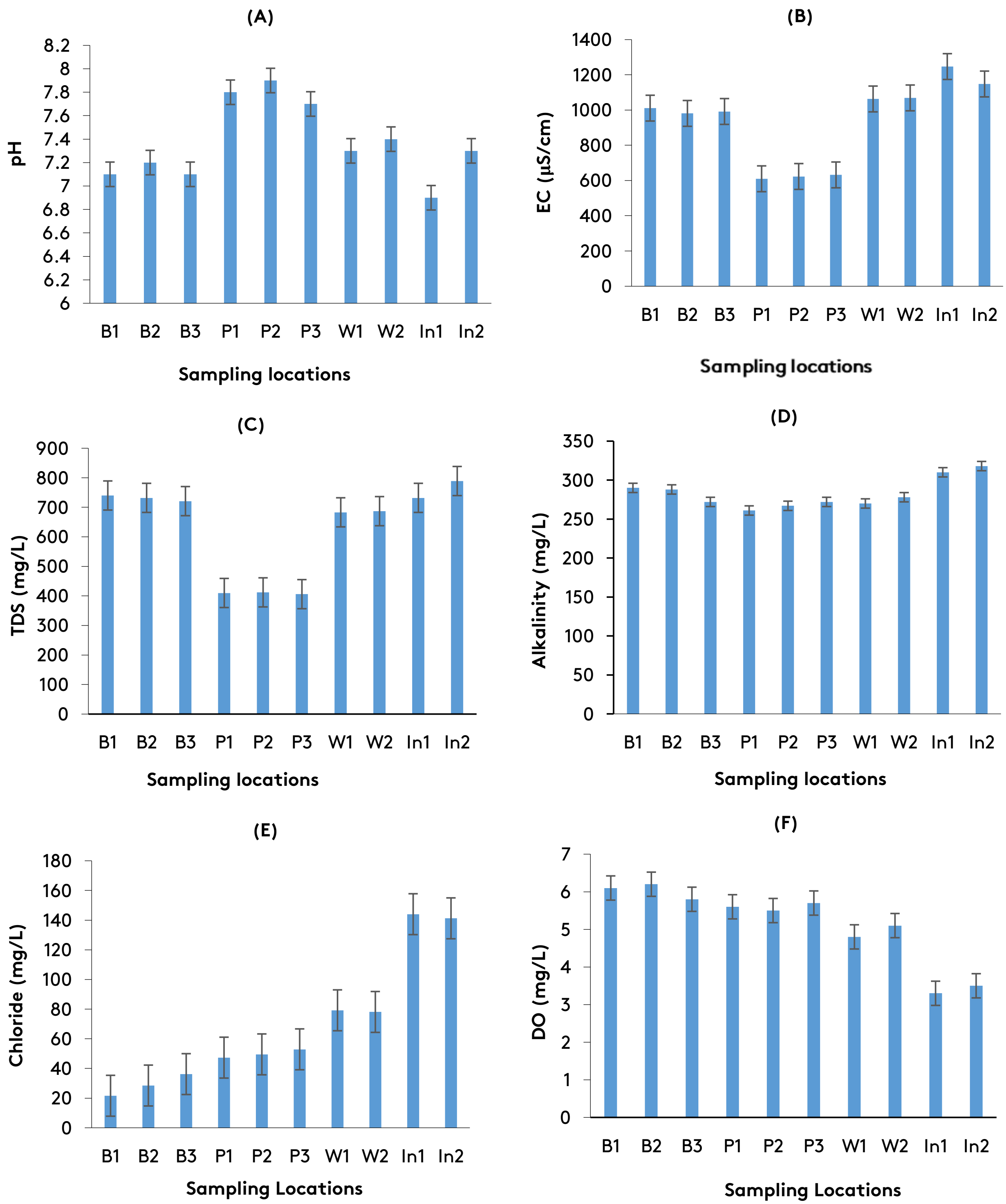

Fig. 4. Status of the study area water quality during pre-monsoon, (A) pH; (B) Electrical Conductivity (EC); (C) Total Dissolved Solid (TDS); (D) Alkalinity; (E) Chloride; (F) Dissolved Oxygen (DO).

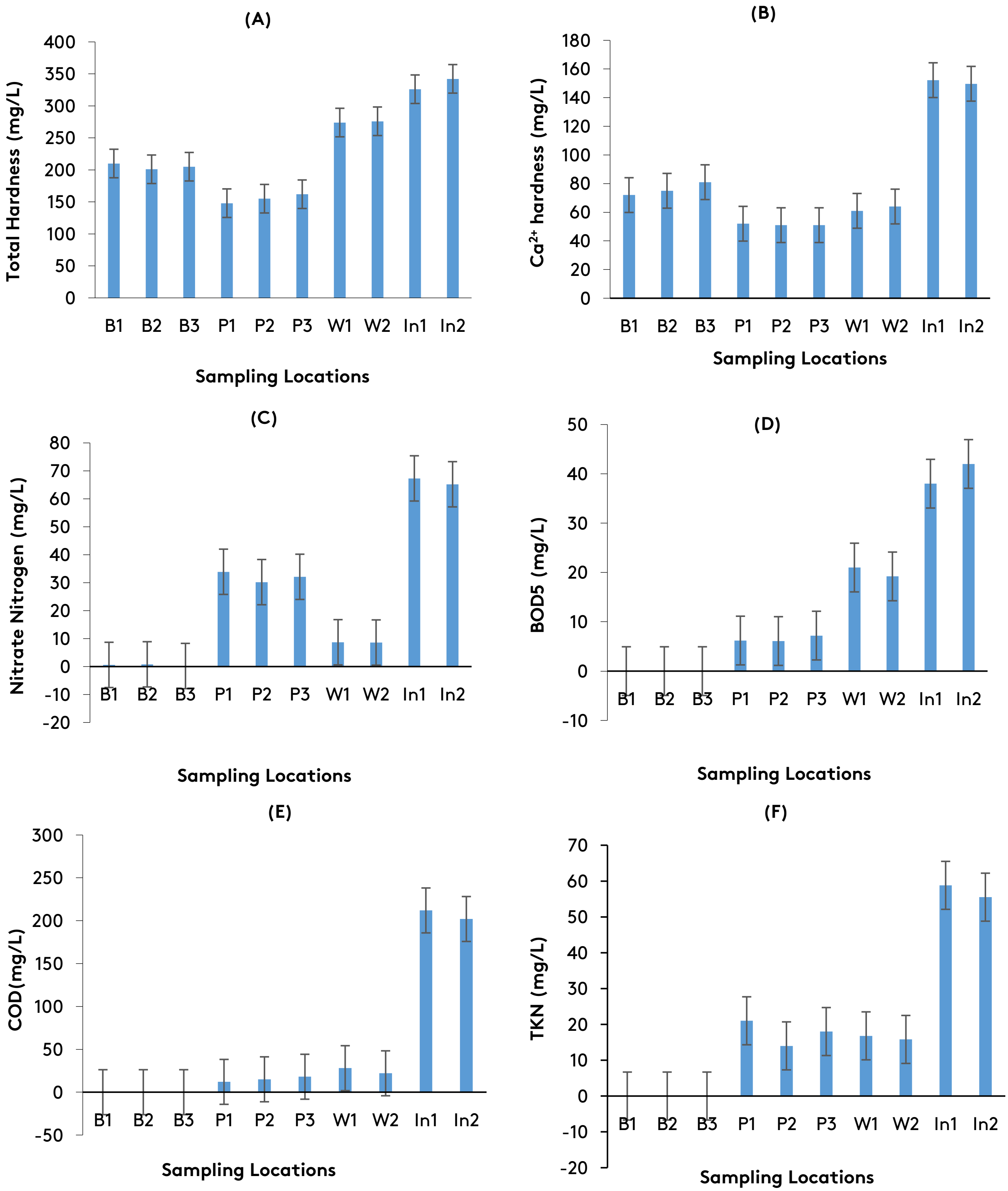

Fig. 5. Status of the study area water quality during pre-monsoon, (A) Total Hardness; (B) Ca^{2+} Hardness; (D) Biological Oxygen Demand (BOD_5); (E) Chemical Oxygen Demand (COD); (F) Total Kjeldahl Nitrogen (TKN); and (G) Total Phosphorus (TP).

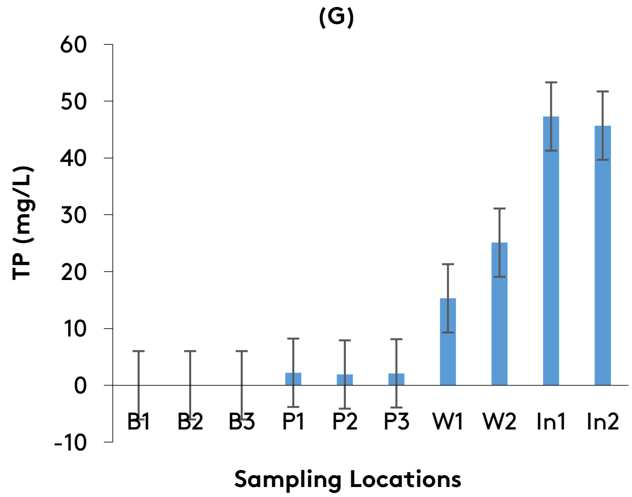

Fig. 5. Continued

The study area's Ca^{2+} hardness value ranged from 51 to 152.2 mg/L. The standard limit of Ca^{2+} hardness was 500 mg (WHO). DO is a crucial metric since it serves as a gauge of water quality. Between 3.5 and 6.2 mg/L of DO were present in the water of the study area. In the current study, bore samples (B1, B2, and B3) included the highest levels of DO, whereas sample In1 contained the lowest levels (Figure 4 F). BOD_5 is usually defined as the requirement of oxygen for bacteria while stabilizing decomposable organic matter under aerobic conditions and essential for measuring the oxygen consumed by microorganisms under aerobic conditions [24]. The BOD_5 value found in the study ranged from 6.1 mg/L to 42.5 mg/L (Figure 5 D) and the COD from 15.0 mg/L to 207.0 mg/L, which was under CPCB norms. BOD_5 and COD were lower in pond water as compared to the influent of sewage, which showed the proper functions of the natural wetland systems. The RE of BOD_5 and COD through the wetland was respectively 50% and 87.9% (Table 2). The RE of BOD_5 and COD through the pond were 72.6% and 40%, respectively. This data showed that the wetland treated the domestic and industrial wastewater satisfactorily. A COD test was used to measure the organic strength of industrial and domestic waste. The COD ranged from 12 mg/L to 212 mg/L in the study area. The plants available in the wetland and ponds effectively aerate the filtration system. In the study area, the ratio of BOD5/COD was 0.2 in the influent, which showed the slowly biodegradable wastewater treatment; after treatment through the wetland, this ratio was more than 0.5, making it easily biodegradable for the WW [19,26]. The quantity to which pollutants were reduced during the treatment process depended upon the existing condition of the wetland, the slope of the study area, and the strength of the influent WW. All nutrients (nitrogen and phosphorus) were natural parts of aquatic ecosystems. TKN is the form of organic nitrogen and ammonia. Organic nitrogen contains natural materials such as protein, nucleic acid, urea, and peptides [14]. The range of the TKN was 14.0 mg/L to 58.8 mg/L, and the TP was 1.9 mg/L to 47.3 mg/L. The higher level of nutrients was due to the vegetable market near the study area. The RE of TKN and TP through the wetland were 71.4 % and 56.5%, respectively. TKN and TP were absent in all the samples of groundwater. The majority of the nitrate in the ponds originated from inflowing streams, which were an external source of nitrogen [21]. NN was available in all samples, ranging from 0.2 mg/L to 67.3 mg/L. Due to the adequate amount of nutrients in the influents, algal and aquatic plants have developed in the study area. When dead algae undergo decomposition, organic nitrogen is released, as shown in the wetland and pond samples. The RE of NN through the wetland was 82.7%. NN is generally low in groundwater because of the absorbance of clay and soil particles. In the study area, NN was available in groundwater compared to the wetlands and ponds. People around the pond use the pond for bathing, washing clothes, and fishing. Dissolved organic matter surfactants and chlorite are the major interference of NN (APHA). Swarnakar et al. [28] studied various soil-based constructed wetlands that had a higher RE of nutrients and enhanced the DO in the effluents. Due to the good level of DO, many varieties of fish are available in the wetlands and ponds. Fish farming is done commercially in the ponds and wetlands. The details of the fish present in the wetlands and ponds are given in Table 4, with their local name and scientific name [29]. Turtles are also found in both water bodies.

Table 4. Details of fish available in wetland and pond.

S. No.	Wetland	Pond
1.	Tengna (Mystus Tengara)	Tilapia (Oreochromis niloticus)
2.	Singhi (Stinging catfish)	Rohu (Labeo rohita)
3.	kemi (Hiligaynon)	Catla (Catla Catla)
4.	Bhunda (Murrel)	Komalkar (Kaman Kar)
5.	Mongri (Clarias batrachus)	Singhi (Stinging catfish)
6.	Kotri (Mahseer)	kemi (Hiligaynon)

5. Conclusions

In this study, it can be observed that urban WW can be treated by wetland. The treated water is collected in a pond, which improves the water quality and has no impact on groundwater. In terms of the environment, the wetland and pond's measured water quality parameters, such as pH, EC, TDS, alkalinity, hardness, Ca^{2+} hardness, and DO, showed the improvement of the water quality. The mean DO value of the pond was under 5.0 mg/L, and the DO value at some points in the pond had a good standard value (>5–6 mg/L), which is good for fisheries. The existing wetland is treating WW properly. As per the findings, organic matter and nutrients were removed by the wetland and pond by more than 50%. The quality of pond water could be improved by adding more plants to improve the wetland water body. Pond water and aesthetics could be improved by adding some water lilies. All borewell water is drinkable and does not require extra treatment. It is necessary to undertake additional research using biotic indices to determine how humans have impacted different BOD_5 ecosystems throughout the pre-monsoon and post-monsoon seasons. No problems of any kind due to the use of groundwater have been reported by the residents of the study area. Therefore, it could be concluded that the watersheds in the study area are a great example of a natural purification system for WW via the wetlands.

Declaration of Competing Interest

The authors certify that none of their known financial conflicts of interest or close personal ties influenced the research presented in this study.

Acknowledgements

No organization has financed this research. The authors' personal interests drove their entire body of work. The authors are thankful to Mr. Vishal Kumar and Mr. Mohmad Askari for his help in sampling from the field.

References

[1] CPCB (2021). National Inventory Treatment Plant. https://cpcb. nic. in/ status- of- stps/. Accessed Sept 2021.

[2] ENVIS Centre of Hygiene, Sani., Sewage Treat. Sys. and Tech.(n.d.). National status of wastewater gen. and treat. http://www. sulab henvis. nic. in/ Datab ase/ STST_ waste water_2090. aspx. Accessed Sept 2021.

[3] Karathanasis A.D., Potter C.L., Coyne M.S. (2003). Vegetation effects on fecal bacteria, BOD5, and suspended solid removal in constructed wetland treating domestic wastewater. *Ecological Engineering, 20*, 157-169. https://doi.org/10.1016/S0925-8574(03)00011

[4] Keffala, C., Ghrabi, A. (2005). Nitrogen and bacterial removal in constructed wetlands treating domestic wastewater. *Desalination, 185*, 383-389. https://doi.org/10.1016/j.desal.2005.04.045

[5] Klomjek, P., Nitisoravut S. (2005). Constructed treatment wetland: A study of eight plant species under saline conditions. *Chemosphere, 58*, 585–593. https://doi.org/10.1016/j.chemosphere.2004.08.073

[6] Lesage, E. (2006). *Behaviour of heavy metals in constructed treatment wetlands* (Doctoral dissertation, Ghent University).

[7] Swarnakar, A. K., Bajpai, S., Ahmad, I. (2022, June). Various Types of Constructed Wetland for Wastewater Treatment-A Review. In *IOP Conference Series: Earth and Environmental*

Science (Vol. 1032, No. 1, p. 012026). IOP Publishing. https://doi.org/10.1088/1755-1315/1032/1/012026

[8] Tamrakar, A., Upadhyay, K., Bajpai, S. (2022, June). Spatial variation of Physico-chemical parameters and water quality assessment of urban ponds at Raipur, Chhattisgarh, India. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1032, No. 1, p. 012034). IOP Publishing. https://doi.org/10.1088/1755-1315/1032/1/012034

[9] Swarnakar, A. K., Choubey, S. (2016). Testing and analysis of pond water in Raipur City, Chhattisgarh, India. *International Journal of Science and Research*, *5*(4), 1962-1965. https://doi.org/10.21275/23197064

[10] Sharma P., Dubey A., Chatterjee S. K. (2013). Physico-Chemical Analysis of Surface and Ground Water of Abhanpur Block in Raipur District, Chhattisgarh, India. International *Journal of Innovative Technology and Exploring Engineering, 2*(5), 2278-3075.

[11] Mo, L., Chen, J., Xie, Y. (2023). Wetlands conservation in Beijing of China: Present status and development strategies. *Watershed Ecology and the Environment, 5*, 73-79. https://doi.org/10.1016/j.wsee.2023.01.002

[12] Aharia SM, Yangejehb RJ, Mahvic AH, Shahamatd YD, Takdastane A (2019). A new method for the removal of ammonium from drinking water using hybrid method of modifiedzeolites/catalytic ozonation. *Desalination and Water Treatment, 1*(170),148-57. https://doi.org/10.5004/dwt.2019.24619

[13] Nikpour B, Jalilzadeh Yengejeh R, Takdastan A, Hassani AH, Zazouli MA (2020). The investigation of biological removal of nitrogen and phosphorous from domestic wastewater by inserting anaerobic/anoxic holding tank in the return sludge line of MLE-OSA modified system. *Journal of Environmental Health Science and Engineering,18*,1-0. https://doi.org/10.1007/s40201-019-00419-1

[14] Amini Fard F, Jalilzadeh Yengejeh R, Ghaeni M. (2019). Efficiency of Microalgae Scenedesmus in the removal of nitrogen from municipal wastewaters. *Iranian Journal of Toxicology*. 10, 13(2):1-6. https://doi.org/10.32598/IJT.13.2.483.2

[15] Zangeneh, A., Sabzalipour, S., Takdatsan, A., Yengejeh, R. J., Khafaie, M. A. (2021). Ammonia removal form municipal wastewater by air stripping process: An experimental study. *South African Journal of Chemical Engineering, 36*, 134-141. https://doi.org/10.1016/j.sajce.2021.03.001

[16] Kumar V., Ahirwar A. V. Prasad A. D. (2022, June). Noise Mapping during New Year Eve in selected residential zone of Raipur City. In IOP Conference Series: Earth and Environmental Science (Vol. 1032, No. 1, p. 012030). IOP Publishing. https://doi.org/10.1088/1755-1315/1032/1/012030

[17] Swarnakar AK, Bajpai S, Ahmad I. Evaluation of the performance of different soil-base horizontal subsurface flow constructed wetlands for wastewater treatment. *European Chemical Bulletin, 12*(7), 2023, 1842-1851. https://doi.org/10.48047/ecb/2023.12.7.1412023.14/06/2023

[18] Swarnakar, A. K., Bajpai, S., Ahmad, I. (2021). Geo Physicochemical Properties for Soil Base Subsurface Constructed Wetland System. *AIJR Proceedings*, 228-233. https://doi.org/10.21467/proceedings.112.28

[19] Rezwan, S. M., Chowdhury, M. A. H., Rahman, S. M. (2022). Assessment of ecosystem services, plant diversity pattern, and water quality of an urban water body in Dhaka, Bangladesh. In *Resilient and Responsible Smart Cities: Volume 2* (pp. 151-163). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-86499-6_14

[20] American Public Health Association. (1926). *Standard Methods for the Examination of Water and Wastewater* (Vol. 6). American Public Health Association.

[21] Islam M.S. Rehnuma M. Tithi S.S., Kabir M.H., Sarkar L. (2015). Investigation of water quality parameters from Ramna, Crescent and Hatirjheel lakes in Dhaka city. *Journal of Environmental Science and Natural Resources, 8*(1),1-5.

https://doi.org/10.3329/jesnr.v8i1.24620

[22] Verma, S. K., Sahu, R. T., Singh, H., Prasad, A. D., Verma, M. K. (2022, June). A study of Environmental and Ecological impacts due to Construction and Operation of Tehri-Polavaram Dam. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1032, No. 1, p. 012020). IOP Publishing. https://doi.org/10.1088/1755-1315/1032/1/012020

[23] Pasha A. K., Mustafa S. O., Rahman S. M., Abdullah M., Chowdhury, M. A. H., Parveen, M. (2023). Analysis of Water Quality of Hatirjheel Lake, Dhaka, Bangladesh. Nature *Environment and Pollution Technology, 22*(1), 245-252. https://doi.org/10.46488/NEPT.2023.v22i01.023

[24] Sawyer, C. N., McCarty, P. L., Parkin, G. F. (2003). Chemistry for environmental engineering and science. McGraw-Hill.

[25] Gunes K., Oktar B., Ayaz S., Gunay A.S., Ozden G., Disbudak, K., Tuncsiper B. (2013). Large scale constructed wetland implementation projects in Turkey in Salt Lake Special Environmental Protection Area. *Desalination and Water Treatment, 51*(22-24), 4758-4767. https://doi.org/10.1080/19443994.2013.791779

[26] Swarnakar AK, Bajpai S. (2021). Role of soil organic matter in plant growth for horizontal flow subsurface constructed wetlands for waste water treatment. *Pollution Research, 40*(2), 559-561.

[27] Davis, M. L., Masten, S. J. (2013). Principles of Environmental Engineering. McGraw-Hill Education.

[28] Swarnakar AK, Bajpai S, Ahmad I. Performance Evaluation of Different Soil Media by Batch-Operated Pilot-Scale Horizontal Subsurface Flow Constructed Wetlands for Wastewater Treatment. *Pollution, 9*(4),1567-1578. https://doi.org/10.22059/POLL.2023.357480.1855

[29] Swarnkar, S., Niyazi, A., Sahu, D., Keer, N. R., Singh, J. (2020). Fish Biodiversity Study of Ghongha Dam In Bilaspur District, Chhattisgarh. *Journal of Experimental Zoology India, 23*(2). https://doi.org/10.48047/ecb/2023.12.si4.835

How to site this paper:

Swarnkar, A., Bajpai, S., & Ahmad, I. (2023). Study on the Performance of Wetlands and Impact on Water Quality in a Densely populated Urban Area in Amanaka, Raipur, Chhattisgarh, India. Advances in Environmental Technology, 10(1), 1-11. doi: 10.22104/aet.2023.6442.1760