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RESEARCH ARTICLE

Monitoring planarians in urban water-bodies: does water quality influence planarian abundance?

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Abstract

Aquatic life is under threat due to water pollution driven by urban cities, industries, agrochemicals and pharmaceuticals. Aquatic planarians have been serving as a model system for biomedical research for their remarkable ability of regeneration. Planarians are delicate and sensitive to environmental changes and therefore, monitoring of planarian abundance along with water quality parameters is necessary. In India, there are no studies have been reported on the monitoring of planarian diversity and abundance. The present study aimed to investigate planarian occurrence in three urban water bodies including rivers and lakes, and monitoring physico-chemical properties of water. We selected eleven locations (rivers and lakes) in and around Pune city (Maharashtra, India) for the present study. Among those we monitored three water-bodies throughout the year (June 2022-May 2023) for planarian occurrence and recorded water pH, temperature, salinity, total dissolved solid (TDS), conductivity, turbidity, hardness, alkalinity, dissolved oxygen (DO), bio-chemical oxygen dissolved, and different ions (chlorides, calcium, magnesium, sulphate, and iron). The data collected were presented in graphical tabular format. We recorded planarian (*Dugesia sp*.) occurrence in three water bodies namely Pashan Lake, Mula river, and Bhima River. Interestingly, planarians were present at these locations throughout the year except the heavy monsoon months July and August. The results demonstrated that the water quality properties change drastically throughout the year and were subject to seasonal changes in the water flow. Notably, turbidity and TDS values were high during July and August months possibly due to water runoff. Chlorides, calcium and magnesium concentrations were high during these months. These results suggest that planarian abundance could not be correlated with specific water parameter. Planarian seems to be tolerant to diverse water conditions except high water flow.

Keywords: Planarian; Water quality; Water flow; Monsoon; Urbanization

1. Introduction

Pollution in rivers and lakes has devastative impact on biodiversity (Bashir et al., 2020). Since pollutants are of diverse chemical nature, their composition in water-bodies alters the quality of water. Cumulatively, the composition of the chemical pollutant changes physic-chemical properties of water (Vega et al., 1998; Patil et al., 2012). Each of these chemicals can have deleterious impact of animals. Moreover, chemical composition of water-bodies may have unpredictable impact on animal diversity and abundance. The chemical pollutants induced changes in water quality properties can influence diversity and abundance of both vertebrate and invertebrate animal diversity (Bernanke and Köhler, 2009; Saaristo et al., 2018; Mukhtorova et al., 2023). Therefore, monitoring animal diversity of water-bodies along with physicochemical properties is important.

Among invertebrates, planarians are unique as they have super-power of regeneration. There are more than 1500 species of planarians thrive in aquatic environments. These flat worms have long evolutionary history and have been adapting almost all natural deserters (Bely and Nyberg, 2010; Tiozzo and Copley, 2015). However, in modern era, they are being exposed to diverse chemical as well as neutral pollutants such as micro-plastics (Walunj and Kshirsagar, 2024). Several studies have demonstrated that planarians are able to survive diverse chemical exposure in natural as well as laboratory conditions (Alonso and Camargo, 2015). Although planarians have superpower of regenerations, modern pollutants of diverse chemicals nature can surpass natural powers of animals and affect their survival (Li, 2008; Simão et al., 2020; Wu et al., 2024). Moreover, survival and abundance of planarians in polluted and non-polluted water-bodies have rarely been studied (Knakievicz, 2024). In addition, studies on the monitoring of aquatic planarians in natural habitat are lacking (Barzaghi et al., 2021).

India is a mega-diverse country having two biodiversity hotspots with high concentration of endemic vertebrate and invertebrate fauna (Aravind et al., 2007; Venkataraman and Sivaperuman, 2018). However, there are no studies on the taxonomy and diversity of planarian in India (Walunj and Kshirsagar, 2024). Considering these lacunae, there is an urgent need of preliminary studies focusing on the occurrence of the planarians in the natural water-bodies facing pollution issues due to urbanization and industrialization.

In the present study, we monitored eleven urban water-bodies in and around Pune metropolitan city for the presence of planarians for a period of six months. After that we monitored three water-bodies (Pashan lake, Mula river, and Bhima River) with the presence of planarians throughout the year. We also studied physico-chemical properties of these three water-bodies and discussed the results in context of water quality and planarian presence.

2. Material and method

2.1. Study site and monitoring of Planarian species

For the present study, we selected eleven locations in around Pune city including four rivers and one lake (Figure 1). Following are the locations selected for the present study, Pashan Lake, PMC, Aundh, Pimple Gurav, Rajgurunagar, Vitthalwadi, Deccan, Yerwada, Wadgaon Sheri, Thergaon and Koregaon Park (Figure 1). Among these selected sites Pashan Lake is a small dam constructed on Ramnadi River and remaining locations are flowing river sites. During preliminary surveys, we visited these sites during each month for six months. Among those, the presence of planarian species was recorded at three locations, Pashan Lake, Aundh, and Rajgurunagar. These three sites were further monitored throughout the year during June 2022-May 2023 for the presence of planarian.

2.2. Measurement of physico-chemical parameters of water

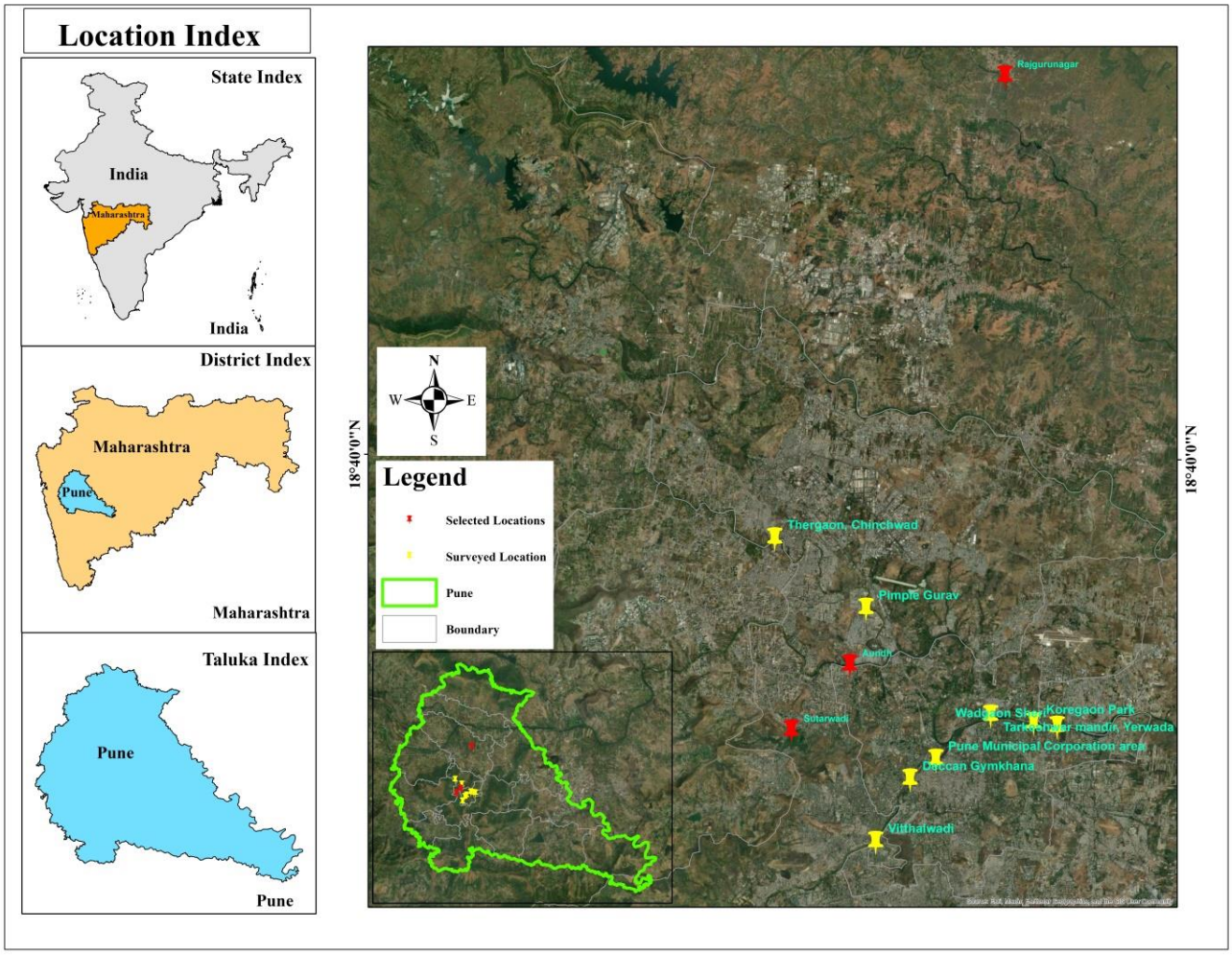

Figure 1. (A) Map showing geospatial locations of the collection sites in the Pune district. Red coloured pins represent the locations where planarian found, (B and C) Photomicrograph of planarian.

Figure 2. Study locations for the monitoring of the presence of planarians and different water parameters. (A) Pashan lake – Ramnadi river, (B) Aundh – Mula river (C) Rajgurunagar – Bhima River, and (D) Live Planarian on Hyacinth stem.

We also recorded physico-chemical parameters of these water-

Table 1. Month-wise occurrence of Planarian species in Pashan Lake, Mula river and Bhima River at Pashan, Aundh and Rajgurunagar, respectively.

	Pashan Lake	Mula River	Bhima River
January	+	+	+
February	+	+	+
March	+	+	+
April	+	+	+
May	+	+	+
June	+	+	+
July	-	-	-
August	-	-	-
September	+	+	+
October	+	+	+
November	+	+	+
December	+	+	+

Table 2. Summary of water quality properties of Pashan Lake, Mula river and Bhima River at Pashan, Mula and Bhima, respectively.

	Aundh	Pashan	Rajgurunagar
Temperature (°C)	27.01 (23.9 - 33)	25.92 (22.1 - 29.4)	26.52 (24.5 - 29.7)
pH	7.29 (6.83 - 7.92)	7.36 (6.81 - 8.89)	7.35 (6.63 - 8.5)
Electric Conductivity (uS/cm)	642.16 (223 - 870)	769.83 (637 - 950)	555.83 (313 - 1060)
Turbidity (NTU)	2.72 (1 - 7.4)	5.36 (1 - 25)	1.91 (1 - 25)
Total Dissolved Solids (ppm)	454.91 (158 - 588)	560.66 (452 - 744)	415 (222 - 754)
Salinity (ppm)	320.16 (108 - 496)	379 (310 - 493)	286.5 (151 - 517)
Total Hardness (mg/L)	214.16 (108 - 342.5)	232.98 (137.6 - 281.6)	192.76 (112.8 - 328)
Total Alkalinity (mg/L)	253 (110 - 385)	286 (220 - 363)	254.83 (143 - 385)
Chlorides (mg/L)	51.3 (14.18 -107)	54.76 (28.36 -103.38)	36.79 (10.63 -102.8)
Calcium (mg/L)	51.21 (16 - 94.5)	54.09 (25.1 - 82.83)	53.60 (16 - 150)
Magnesium (mg/L)	33.55 (6.59 - 128)	32.88 (8.7 - 128)	34.62 (6.5 - 170)
Sulphate (mg/L)	116.71 (12.5 - 200)	94.80 (11.11 - 170)	68.70 (10.24 - 150)
Iron (mg/L)	0.1 (0.04 - 0.2)	0.10 (0.036 - 0.2)	0.08 (0.02 - 0.2)
Dissolved Oxygen (mg/L)	8.41 (0.5 - 16.7)	5.85 (0.8 - 15.2)	6.08 (1.6 - 12.5)
Bio-Chemical Oxygen Dissolved (mg/L)	34.27 (6.97- 75)	21.39 (13 - 30)	23.79 (5.4 - 33)
Most Probable Number per/100 ml	24.83 (7 - 35)	22.75 (11 - 35)	23.66 (4 - 35)

bodies including water pH, temperature, salinity, total dissolved solid (TDS), conductivity, turbidity, hardness, alkalinity, dissolved oxygen (DO), bio-chemical oxygen dissolved (BOD), and different ions (chlorides, calcium, magnesium, sulphate, and iron). pH, temperature, conductivity, salinity and TDS were measured on field using portable multi-parameter probe PCSTestr 35 (Oakton). Hardness and alkalinity of the water were determined. DO and BOD were estimated using Winkler's method. Chlorides, calcium, magnesium, sulphate, and iron were estimated following the guidelines established by American Public Health Association (Varma and Srivastava, 2012; Lipps et al., 2023). The data collected were statistically analysed and presented in graphical tabular format.

3. Results

3.1. Occurrence of Planarians in urban water bodies

Present study has revealed abundant presence of planarian species at three locations of urban water bodies except in July and August (Figure 1; Table 1). Further, analysis revealed the presence of a single species of the planarians, *Dugesia* sp (Figure 2). Planarians were absent at all three locations during July and August.

3.2. Physico-chemical parameters of water

The highest average annual temperature was recorded at the Aundh site followed by Rajgurunagar and Pashan (Table 2). We observed a similar trend in the water temperature of three selected water bodies throughout the year. Notably, the highest water temperature was observed in April at the Aundh site followed by Rajgurujnagar in October (Figure 4A). Average pH values of the three sites were comparable among the sites (Table 2). There was a similar trend in the pH of water at different locations throughout the year except for the highest pH recorded in June at Pashan Lake (Figure 4B). The highest average electric conductivity (EC) was observed at Pashan Lake and the lowest EC was observed at Rajgurunagar site (Table 2). EC was similar throughout the year at Pashan Lake while it was highly fluctuated at the sites Aundh and Rajgurunagar during the monsoon and post-monsoon months (Figure 4C). The highest turbidity was observed at Pashan Lake followed by Aundh and Rajgurunagar (Table 2). Turbidity was observed to be similar throughout the year at the Aundh site while

Figure 3. Planarian *Dugesia sp*. recorded in the present study site. Photographed using Oppo smartphone F21 Pro.

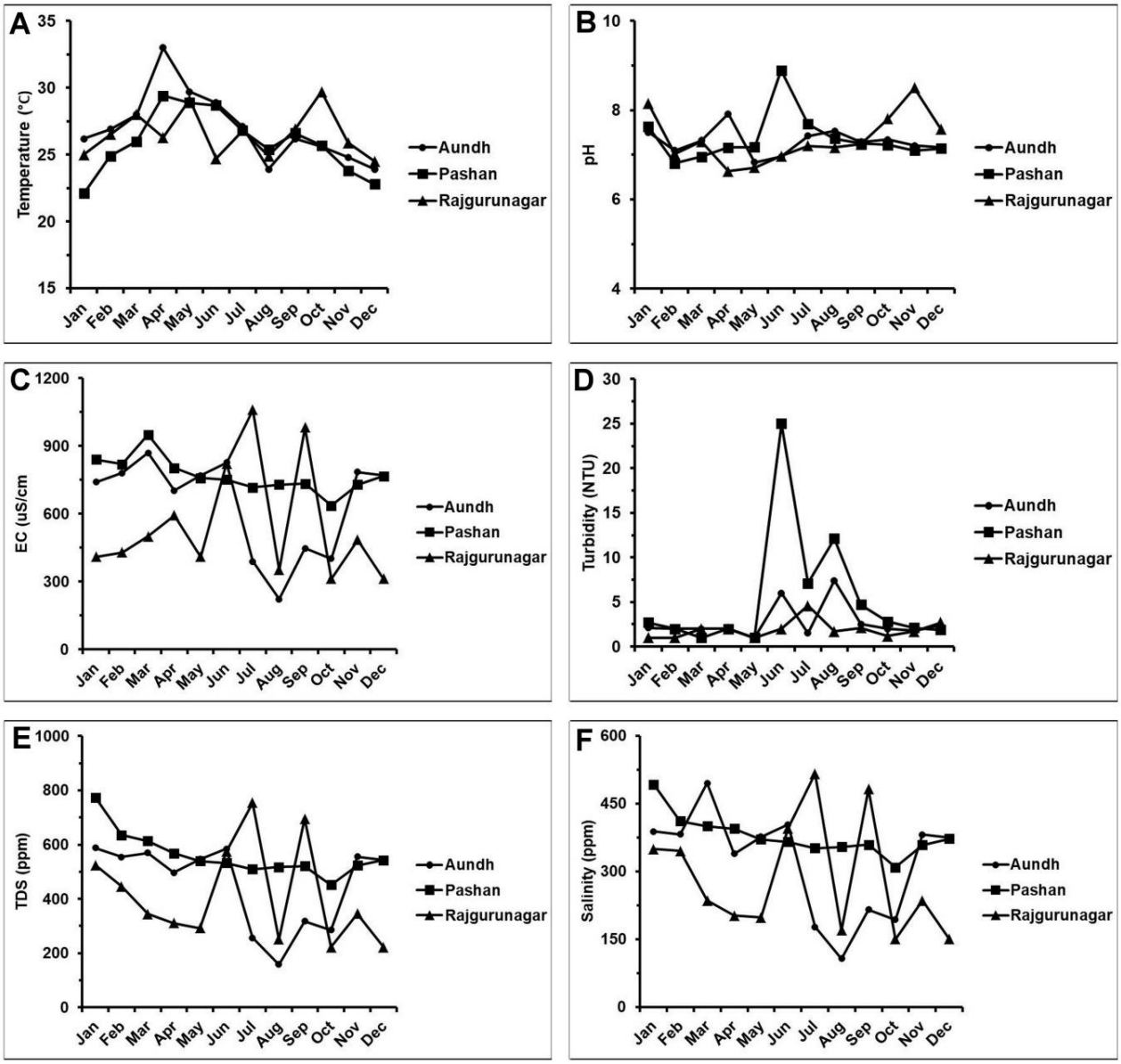

Figure 4. Temperature, pH, electric conductivity (EC), turbidity, total dissolved solid and salinity of Pashan Lake, Mula river and Bhima River at Pashan, Aundh and Rajgurunagar, respectively.

it was highest at Pashan Lake during June followed by at Rajgurunagar during November (Figure 4D). Total dissolved solid values were highest at Pashan Lake and the lowest TDS values were observed at Rajgurunagar site (Table 2). TDS ranged between 800 ppm to 500 ppm at the Pashan site while it was found highly fluctuated at the Rajgurunagar site during the monsoon and post-monsoon months followed by the Aundh site (Figure 4E). Average salinity was found not considerably different among the three sites. The values of salinity did not fluctuate considerably at Pashan Lake while they significantly fluctuated throughout the year at Aundh and Rajgurunagar sites.

There was no considerable difference in the hardness of the water. Notably, the average hardness of the water was high at Pashan Lake (Table 2). The hardness of the water fluctuated throughout the year at all sampling sites (Figure 5A). Average total alkalinity of the river sites (Aundh and Rajgurunagar) was similar while it was high at Pashan Lake (Table 2). The alkalinity of the water at Pashan Lake was fairly constant throughout the year while it fluctuated at Rajgurunagar (Figure 5B). The highest average dissolved oxygen and BOD were recorded at the Aundh site followed by Rajgurunagar and Pashan Lake (Table 2). High dissolved oxygen levels were observed during April and May months at all sites while it was low at Pashan Lake during the monsoon and post-monsoon months (Figure 5C). BOD was constant throughout the year at Pashan Lake and Rajgurunagar while it was highly fluctuated at Aundh site (Figure 5D).

Average concentrations of chlorides and calcium were highest in Pashan Lake while the lowest concentration of chloride was recorded at Rajgurunagar and the lowest concentration of calcium was recorded at the Aundh site (Table 2). Chloride concentrations fluctuated at all sites throughout the year being lowest during summer and post-monsoon months at all study sites (Figure 6A). Calcium concentrations fluctuated at all sites throughout the year. The highest calcium concentration was recorded at Rajgurunagar during June while the lowest calcium concentrations were recorded in April at Aundh and Rajgurunagar sites (Figure 6B).

There was no considerable difference in the average magnesium concentrations at different sites (Table 2). Magnesium concentrations were high during May and June at all sites being slightly highest at Rajgurunagar throughout the year (Figure 6C). The highest sulfate concentration was recorded at the Aundh site followed by Pashan Lake (Table 2). Sulfate concentrations were high in the late winter and summer seasons at all sites where the highest concentration was recorded in January at Aundh and the lowest concentrations were recorded in November at all locations. The concentration of iron was similar at Aundh and Pashan Lake while it was low at Rajgurunagar (Table 2). There was a similar

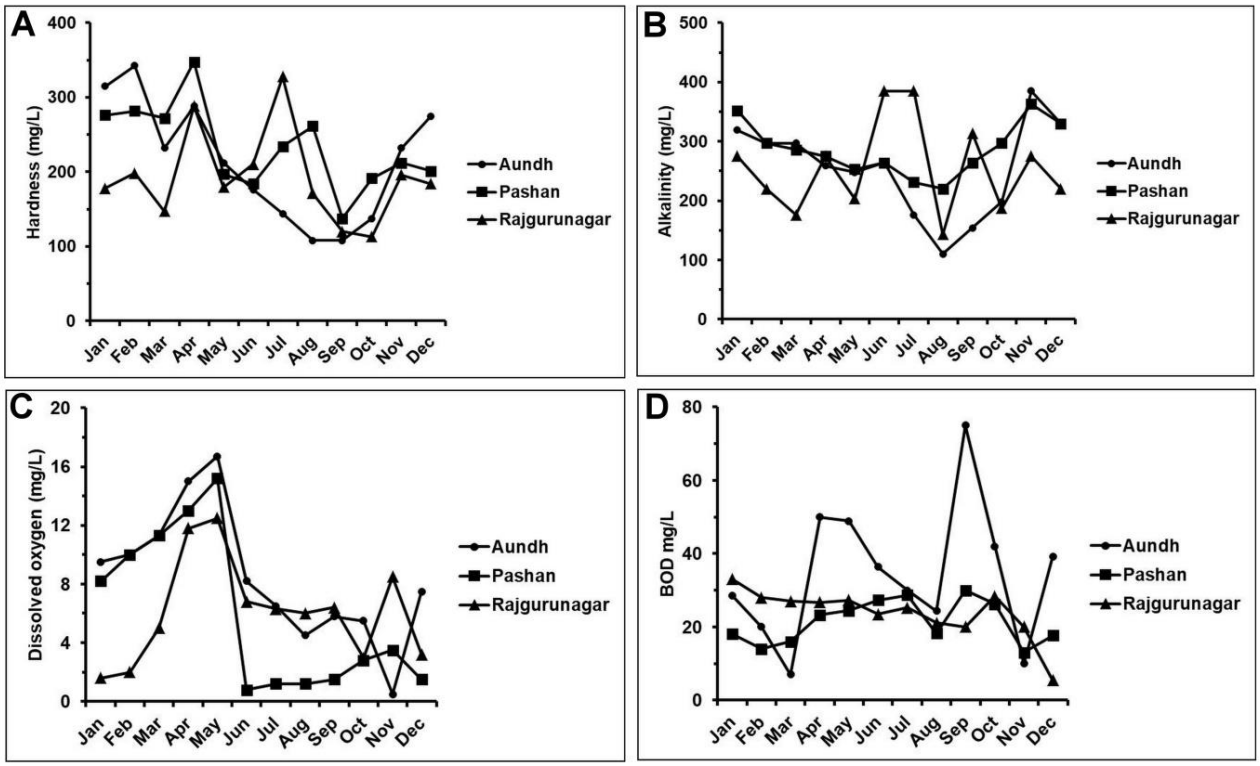

Figure 5. Hardness, alkalinity, dissolved oxygen (DO) and bio-chemical oxygen dissolved in the water of of Pashan Lake, Mula river and Bhima River at Pashan, Aundh and Rajgurunagar, respectively.

trend in the concentrations of iron at all study sites with the highest values during April (Figure 6E).

4. Discussion

We monitored water quality using various physico-chemical water parameters of the urban water bodies inhabited by planarians and found that the planarians are abundantly present at these three locations throughout the year except July and August. The rivers included in the present study originated in the Northern Western Ghats. Northern Western Ghats and Pune city receive heavy rain during the peak monsoon months July and August. During these months, rivers flow with their full capacity. The possible reason for the absence of planarians during these months could be the flow of the river water. Previous studies have demonstrated the influence of river flow on invertebrate diversity (Garcia et al., 2012; Datry et al., 2014; Greenwood and Booker, 2015). Previous studies also reported the absence of planarians in water currents (Allen, 1915).

Water quality parameters fluctuated drastically at Rajgurunagar and Aundh sites except Pashan lake depending on the monsoon season. EC, turbidity and TDS values at Pashan lake were not considerably fluctuated as compare to the Rajgurunagar and Aundh locations as these two locations are the river sites. Among these sites, Aundh and Rajgurunagar are river sites and Pashan lake is a dam on a small river that hardly flows for two to three months during monsoon. Moreover, Aundh site is located in urban city and Rajgurunagar is sub-urban location. Among these three sites Pashan lake and Aundh (Mula river) receive discharge containing industrial waste water, urban sewage water, pharmaceutical and agricultural waste water as compared to Rajgurunagar site (Bhima River). Industrial discharge, urban sewage waste, and agricultural runoff can significantly impact water quality of the water (Willis and McDowell, 1982; Nedeau et al., 2003; De Medeiros et al., 2017). In the present study, hardness and alkalinity of the Pashan lake increased while DO and BOD values decreased. Contrastingly, hardness and alkalinity of both remaining river locations was low as compared to the Pashan lake and comparable in between. Interestingly, DO and BOD at Aundh and Rajgurunagar were fluctuating throughout the year and higher as compared to the Pashan lake. These results are in accordance with the previous studies confirming that fluctuation of water quality parameters during monsoon or different seasons can differ in between lakes and rivers (Solaraj et al., 2010; Srivastava et al., 2011; Sharma et al., 2021). Combined these factors (monsoon and pollution) can have significant impact on invertebrate diversity and abundance in lakes and rivers (Basu et al., 2018; Begum et al., 2023; Ghosh et al., 2018; Sharma and Behera, 2022).

We observed similar trend in the concentration of Magnesium, Sulphate, and Iron among all three water-bodies. Similarly, chloride and calcium have similar trends at Pashan lake and Aundh sites. However, calcium and chloride values were comparatively high at Rajgurunagar during early monsoon months (June and July). It seems that high concentration of calcium and chloride at Rajgurunagar during these months is associated with both season and pollution (Gurumurthy et al., 2015; Maharana et al., 2015; Singh et al., 2008; Thomas et al., 2014). During pre-monsoon months, the river Bhima does not receive flowing water (Mula river flows throughout the year due to urban sewage and industrial discharge) and also receive low urban sewage and industrial discharge. Previously, it has been demonstrated that both urban sewage and industrial discharge influence aquatic animal diversity (Bernanke and Köhler, 2009; Saaristo et al., 2018; Mukhtorova et al., 2023).

5. Conclusion

The present study highlights the presence of planarian in urban lake (Pashan lake), urban river (Mula river) and sub-urban river (Bhima River). It seems that planarians can tolerate wide range of water quality parameters in urban and sub-urban water-bodies (Vila-Farré and C. Rink, 2018). Moreover, the type of water-body does not influence the occurrence of planarian (Roca et al., 1992; Vila-Farré and C. Rink, 2018). Importantly, monsoon driven water-flow in lakes and rivers influence planarian occurrence. Future studies investigating the influence of drastic fluctuations in physico-chemical properties due to seasonal changes need to be explored to understand the impact of urbanization driven pollution on planarian occurrence and diversity.

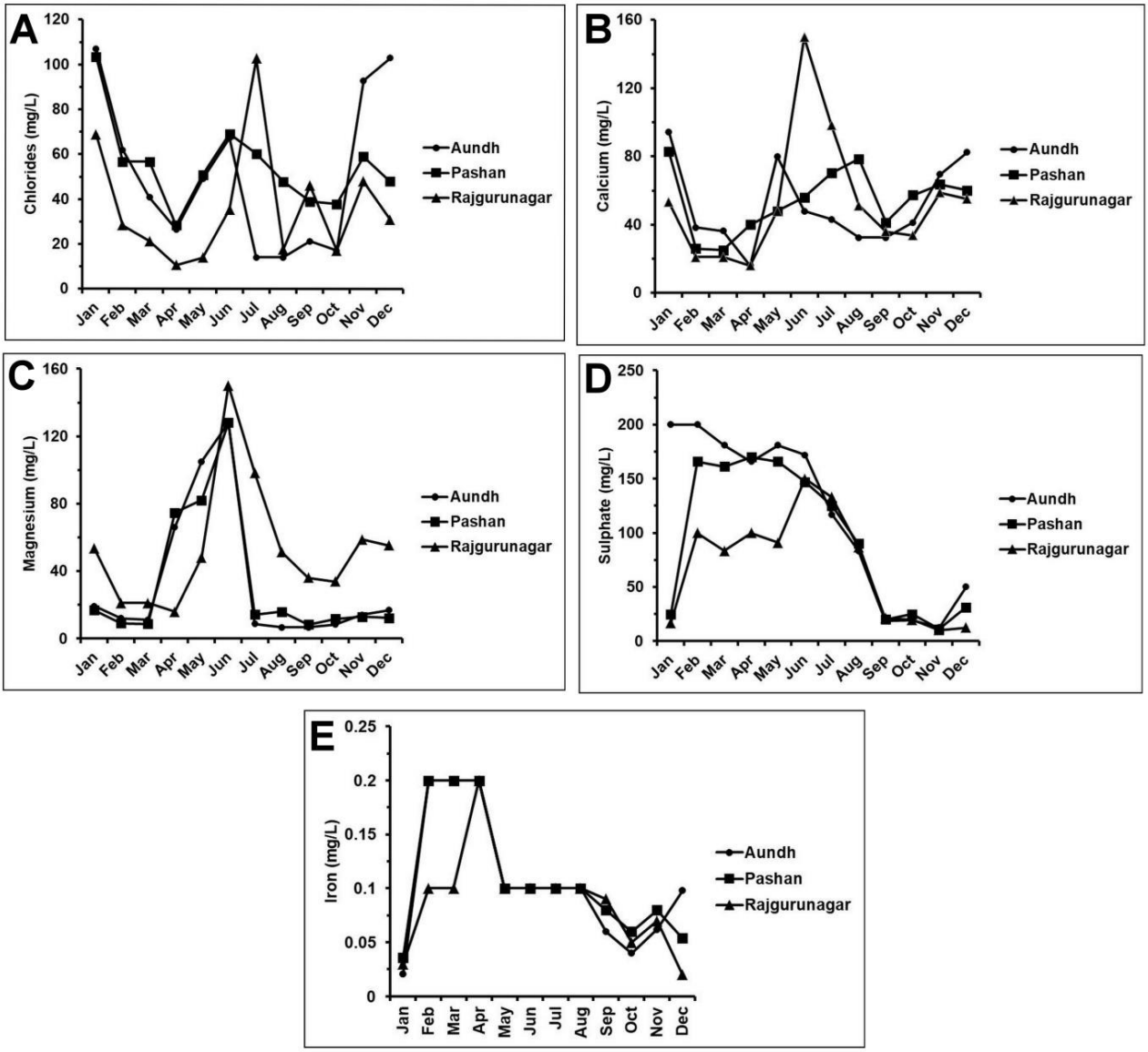

Figure 6. Chlorides, calcium, magnesium sulphate and iron values in the water of Pashan Lake, Mula river and Bhima River at Pashan, Aundh and Rajgurunagar, respectively.

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Author's contributions

Both authors were involved in designed the study, analysis of the results and writing of the manuscript. DW collected laboratory and field data.

Conflict of Interest

Authors have no conflict of interest to declare.

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