Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 December 2022 doi:10.20944/preprints202212.0047.v1

Spatiotemporal effect of land-use on water quality in a peri-urban river basin: a case study at metropolitan region of southeastern Brazil

A. Bressane [1,2*], A.I.S. Loureiro [2], R.C. Gomes [3], A.I. Ribeiro [3], R.M. Longo [4]; R.G. Negri [5]

[1] Environmental Engineering Department, São Paulo State University, 500 Altino Bondensan Road, São José dos Campos/SP, Brazil;

[2] Civil and Environmental Engineering Graduate Program, São Paulo State University, 14-01 Eng. Luiz E.C. Coube Avenue, Bauru/SP, Brazil;

[3] Environmental Sciences Graduate Program, São Paulo State University, 511 March 03 Avenue, Sorocaba/SP, Brazil;

[4] Faculty of Environmental engineering, Pontifical Catholic University of Campinas, Dom Pedro I Road (SP-065), Campinas/SP, Brazil;

[5] Natural Disasters Graduate Program, Brazilian Center for Early Warning and Monitoring for Natural Disasters, 500 Altino Bondensan Road, São José dos Campos/SP, Brazil.

* Corresponding author: adriano.bressane@unesp.br

 doi:10.20944/preprints202212.0047.v1

Spatiotemporal effect of land-use on water quality in a peri-urban river basin: a case study at metropolitan region of southeastern Brazil

Abstract

The suppression of natural spaces due to the urban sprawl and increase of the built and agricultural environments has impacted the water resources quality, especially in areas with high population density, as the metropolitan regions. Considering the advance in Brazilian environmental legal framework, the present study aims to verify whether land use has still significantly affected water quality, through a case study in the Stones River watershed, a peri-urban river basin at a metropolitan region, Brazil. Analysis of physical-chemical indicators, collected at several sample points with different land-use (urban areas, commercial forestry, riparian forestry, mixed vegetation, pasture, and sugar cane plantation) at different seasons of the year (dry and rainy) were carried out. As a result, it was verified some statistically significant spatiotemporal effects on the of water quality caused associated to the land-use. In conclusion, in spite of the advances in the Brazilian law, land-use has still significantly affected the water quality, demanding public policies and decisions, so that effective compliance with legal guidelines is ensured.

Keywords: Anthropization; Environmental impact; Water resource; Land-use.

Introduction

In Brazil, agriculture and urbanization are among the major sources of water resources degradation. Mello et al. (2018) point out that the forest areas is the most important land cover associated with good water quality, in turn the agriculture and urban areas are responsible for its quality degradation. In this sense, the distribution of agricultural land has been an important factor in the distribution of nutrients found in the watersheds, so that areas with higher percentage of this type of land-use are more susceptible to turbidity elevation and total solids (Ni et al., 2021).

The planning and monitoring of watersheds can help control potentially polluting land-uses, but science-based policies and decisions are essential for the effective protection of water quality in Brazil (Mello et al., 2020). To do so, the conservation of natural spaces, as riparian forestry and vegetal coverage, plays a key role in the urban landscape, by acting as a contaminant filter, ecological habitat at riparian zones, to stability of the riverbanks, and reduction of surface runoff (De-Carli et al., 2018). Thus, the conversion of natural areas into other land-uses has affected the protection afforded by forest remnants (Ullah et al., 2018).

On the other hand, in the absence of conservation practices and control of anthropogenic activities, the land-use has degraded the water quality, making the watersheds more impacted due to the effect of polluting loads that affect their capacity for self-purification (Mello et al., 2018). As a consequence, the water for human supply is becoming in several regions of the world, as Brazil due to the poor quality of the available surface resource in urban areas and the high cost of its treatment (Mello et al., 2020).

Based on a review of Brazilian legislation, Bressane et al. (2016) found that environmental protection is widely regulated, and represents one of the main public policy strategies adopted in the country. Despite this, the effectiveness of legal rules applied to land-use control depends on their compliance, especially in areas with high population density, as the metropolitan regions.

Considering the advance in Brazilian legal framework, pointed out by these authors (Bressane et al., 2016), the present study aims to verify whether land-use has still significantly affected water quality, through a case study at metropolitan region of southeastern Brazil. In this sense, the results of the present study were discussed in comparison with the findings from the studies carried out in the same region about 10 15 years ago (Bhutiani and Khanna, 2007; Etto et al., 2013; Göransson et al., 2013; Göransson et al., 2013; Kemerich et al., 2013; Longo et al., 2012; Longo et al., 2013; Souza and Gastaldini, 2014).

Method

The study area corresponds to the peri-urban watershed of Stones River, into Brazilian southwest, a metropolitan region of São Paulo State, at 22º 47 '10 "and 22º 52' 20" S, 47º 07' and 46 ° 02 '55 "W (Figure 1). This region has a subtropical climate, with hot and humid periods in the months of October to April, alternating with cold and dry intervals in the months of May to September. Taking into account the hypothetical seasonal effect, the sampling for water quality analysis was carried out on four moments, October (T01), January (T02), April (T03), and July (T04). In turn, considering the spatial effects, the data were collected in six survey points (P01 – P06), five of which were distributed along the main riverbed and one located in a lagoon affluent to the watercourse.

 doi:10.20944/preprints202212.0047.v1

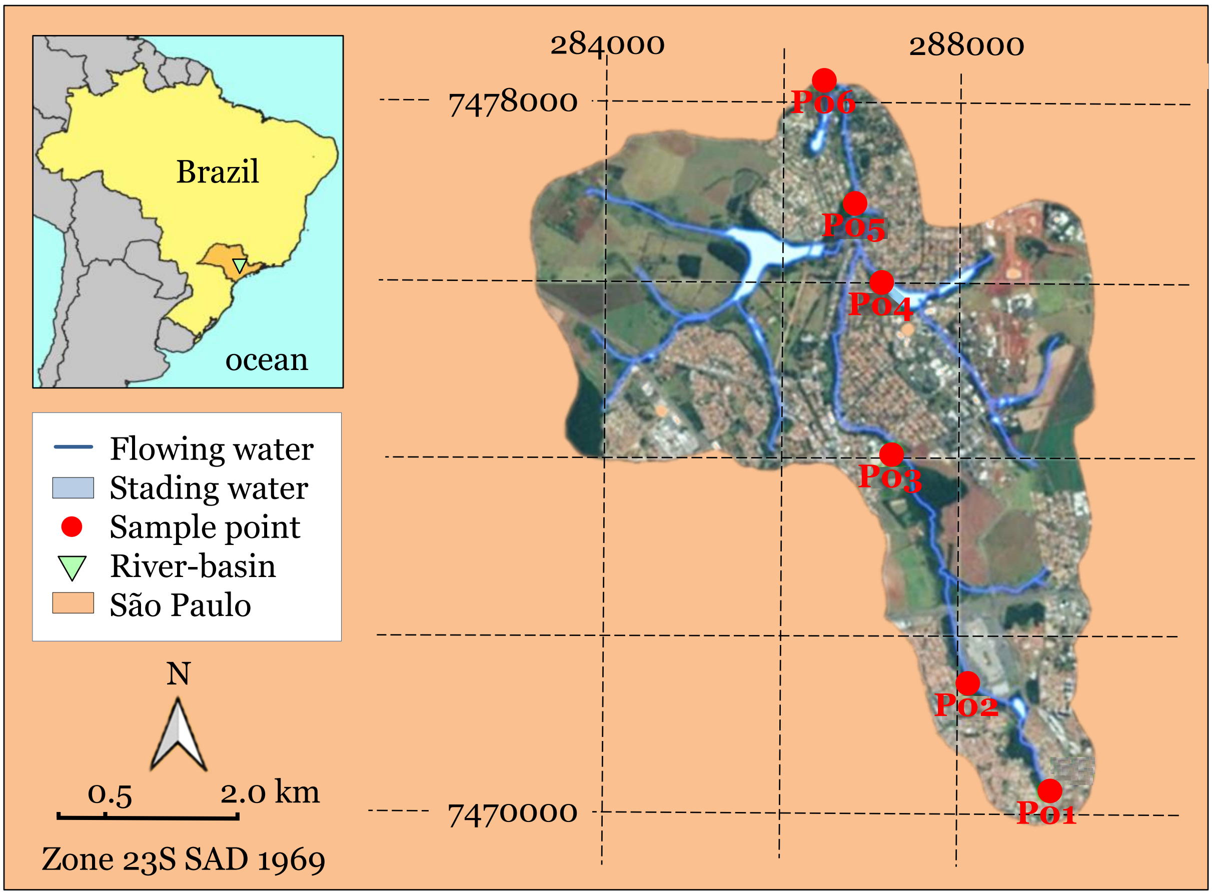

Figure 1. Sampling points at study area.

The first point (P01), further upstream, corresponds to the main source of Stones River, at 22°51'45.84 "S and 47°3'24.64" W. The second (P02) is into the riverbed approximately 1.8 km downstream, adjacent to a large commercial enterprise. At 22°51'2.57 "S and 47°3'56.48" W, P03 it is at the midpoint of the micro-basin (22°49'38.54 "S and 47°4'24.73" W), which receives sediments from agricultural soil, as well as treated effluent from a large enterprise. The fourth (P04) is at 22°48'37.05 "S and 47°04'26.11" W, in a public park adjacent to the main bed of the lotic body. P05 is at the junction of the watercourse with Rhodia highway (22°48'12.73 "S and 47°4'37.25" W), where flooding is observed during periods of intense rainfall. Finally, point P06, further downstream, was collected at 22°47'20.42 "S and 47°4'47.09" W, approximately 50 meters from the mouth of the Anhumas River, an important contributor to the Atibaia River, used to supply adjacent cities. The samples were collected according to the guides of the

 doi:10.20944/preprints202212.0047.v1

National Health Foundation (NHF, 2009) and American Public Health Association (APHA, 2005), being always collected under equivalent conditions, such as at close times, for example.

A total of 12 sample repetitions were collected at each point and, still in the field, the dissolved oxygen and temperature were measured following the guidelines of the NHF and APHA. In turn, pH, turbidity, biochemical oxygen demand, total nitrogen, total phosphorus, and total dissolved solids were analyzed in the laboratory. To verify if the land-use has affected the water quality, a two-factor (seasonal and spatial) analysis of variance, followed by a multiple paired comparisons with Tukey test was carried, considering a significance (α) of 0.05, and test power ($1-\beta$) equal to 0.82 for a sensitivity (ρ) of 50% (detectable effect size), using Jamovi version 2.3, statistical computer software.

Results and discussion

The land-use in the micro-basins of each sample point are shown in Table 1 and Figure 2. Micro-basin areas at P01 and P02 are predominantly urbanized (100 and 89.4%, respectively), with a few or nothing riparian forestry or mixed vegetation (0 and 9.59%, respectively). At P03, the sugarcane plantation occupies around 25% of the micro-basin. In addition to sugarcane (16.08%), pasture area represents 28.6% of the land-use in the P04 micro-basin. Together, the diversified agriculture, sugarcane and pasture area, add up to 43.5 and 40.3% of micro-basins at P05 and P06, respectively.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 December 2022 doi:10.20944/preprints202212.0047.v1

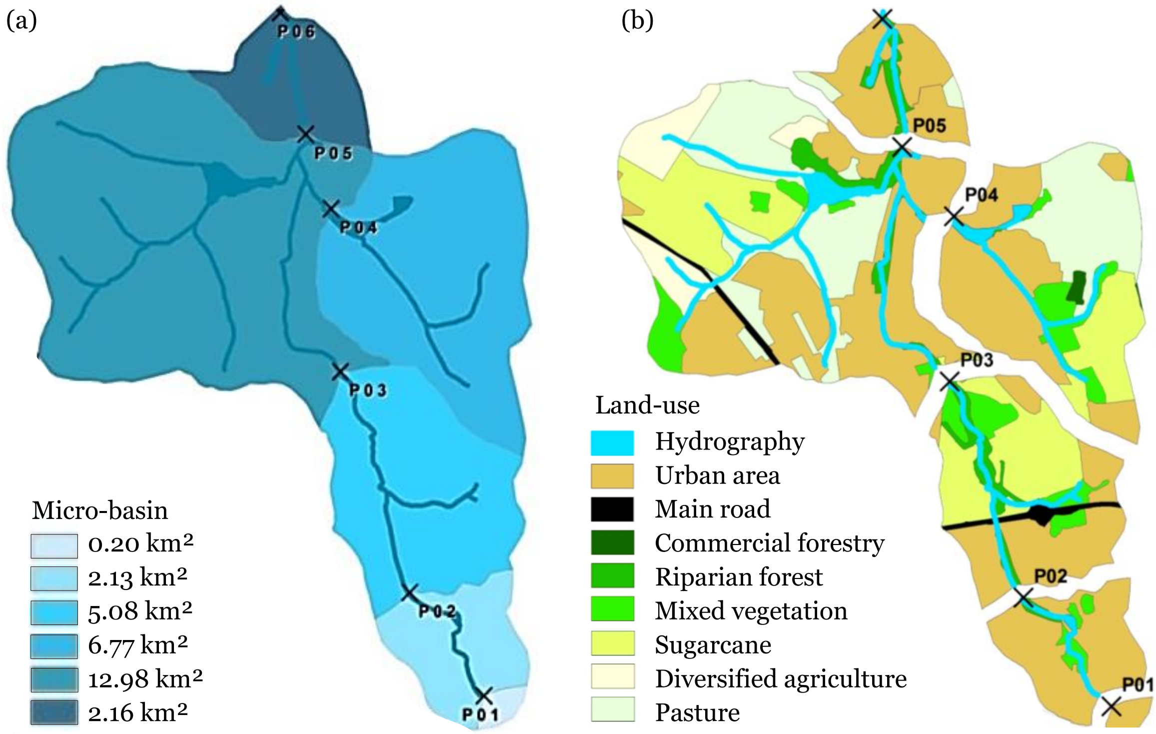

Figure 2. Micro-basin areas (a) and land-use at sampling points.

Table 1. Land-uses in the micro-basin area.

	Sample point (%)					
	P01	P02	P03	P04	P05	P06
Hydrography	-	1.03	0.32	2.16	1.51	1.53
Urban áreas	100	89.38	54.88	42.74	42.86	45.47
Main roads	-	-	3.04	-	1.46	1.36
Commercial forestry	-	-	-	1.20	0.30	0.28
Riparian forestry	-	2.50	6.90	0.07	3.90	4.52
Mixed vegetation	-	7.09	9.91	9.15	7.07	6.55
Sugar cane	-	-	24.94	16.08	18.05	16.73
Diversified agriculture	-	-	-	-	4.77	4.42
Pasture	-	-	-	28.60	20.07	19.15

In general, there is predominant occupation by urbanized areas, followed by agricultural uses, which have significantly impacted these micro-basins, mainly from 1990 (Longo et al., 2013; Etto et al., 2013). The physical-chemical indicators of water quality at sample points are summarized in Figure 3.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 December 2022 doi:10.20944/preprints202212.0047.v1

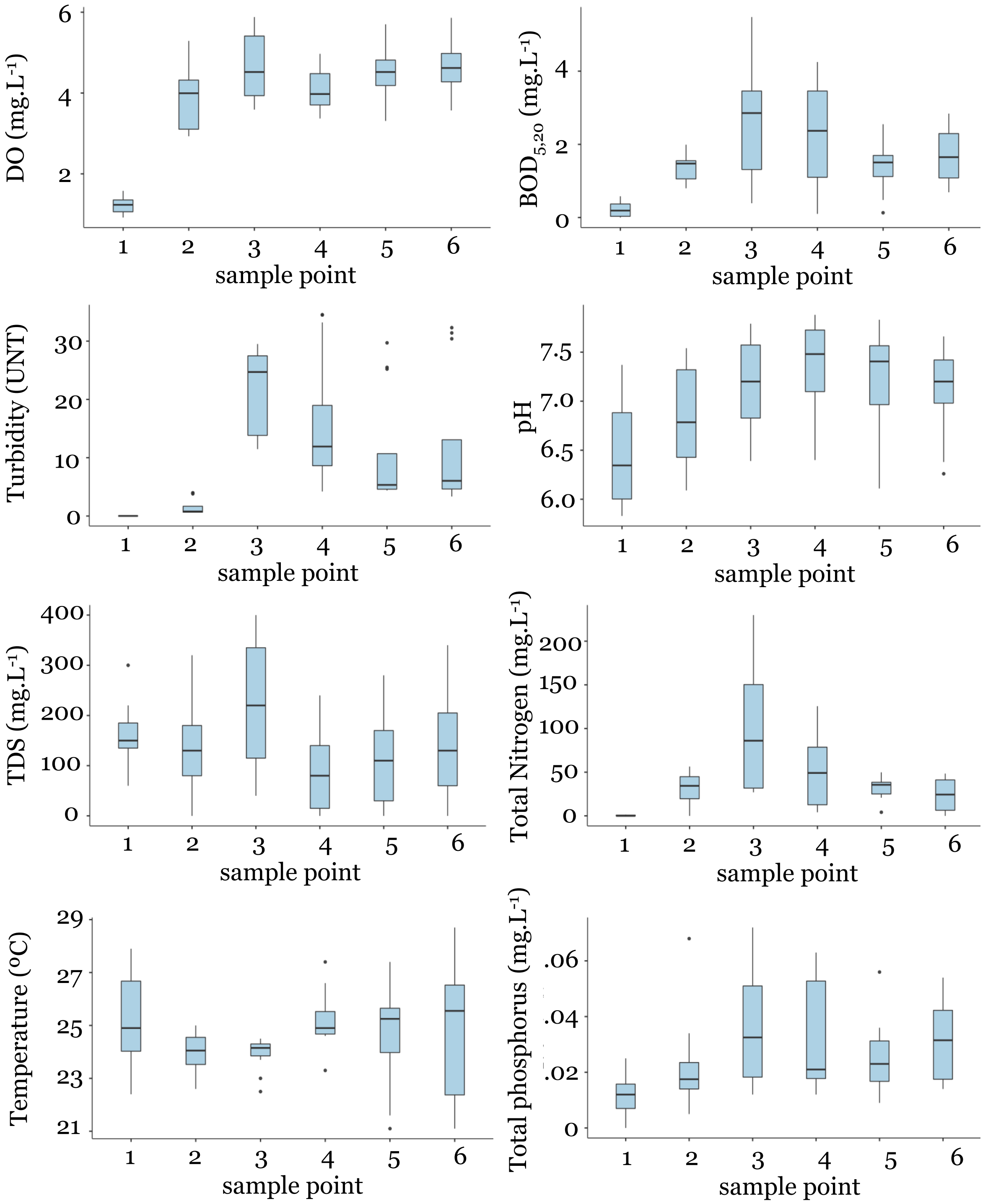

Figure 3. Physical-chemical indicators of water quality at sample points.

From the Figure 3, it can be verified a significant variation of indicator parameters between sample points, indication possible effect caused by different land-use predominant in each micro-basin. In addition, Table 2 shows that only the temperature of the samples in P01 and P06 showed significant seasonal effect, also found years ago, in the study by Göransson et al. (2013).

Table 2. Temperature analysis regarding to spatiotemporal factors.

	Temperature (°C)					
	P01	P02	P03	P04	P05	P06
T01	23.07 bC	23.83 aBC	24.30 aBC	24.70 aBC	25.57 aB	27.50 aA
T02	26.20 aA	23.30 aB	23.33 aB	25.10 aAB	25.97 aA	24.13 bB
T03	26.53 aA	24.10 aB	24.23 aB	26.33 aA	25.10 aAB	26.20 aA
T04	24.73 abA	24.63 aA	23.83 aA	24.73 aA	21.50 bB	21.27 cB

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

The concentrations of Dissolved Oxygen are presented in Table 3. It is observed that in the main headwater this parameter was significantly lower in comparison to the other points, indicating possible effect of land-uses downstream. It is also verified that the concentrations obtained in T04 (July season) were higher, indicating an improvement in the oxygenation of the water associated with the absence of precipitation and the presence of permeable areas, except for headwater and point 2 (P01 and P02), which have practically the entire drainage area waterproofed.

In the sampling of T04, the points P03, P05 and P06 presented the concentrations of 5.68 $mg.L^{-1}$, 5.47 $mg.L^{-1}$ and 5.55 $mg.L^{-1}$, respectively. This increase verified from the P03 can be caused by the agitation of the water due to

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 December 2022 doi:10.20944/preprints202212.0047.v1

the more turbulent flow, verified from this point. It is worth to highlight that P04 is not located in the main riverbed, as the others ones.

Table 3. Dissolved Oxygen analysis regarding to spatiotemporal factors.

	Dissolved Oxygen (mg.L-1)					
	P01	P02	P03	P04	P05	P06
T01	1.44 aC	3.42 bcB	4.54 bA	4.42 abA	4.65 cAB	3.93 bAB
T02	1.05 aC	4.79 aA	4.53 bAB	3.78 bcB	4.57 bAB	4.52 bAB
T03	1.07 aD	3.00 cC	3.98 bAB	3.51 cBC	4.42 cbAB	4.62 bA
T04	1.39 aD	4.15 abC	5.68 aA	4.68 aBC	5.47 aAB	5.55 aAB

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

Table 4 presents the values of the biochemical oxygen demand (BOD), where it can be observed that the month of July (T04) showed a significant decrease in the concentrations, which may be related to the fall in the monthly precipitation as well as to the absence of precipitation 24 days prior to the collection.

Table 4. Bioch. Oxygen Demand analysis regarding to spatiotemporal factors.

	Biochemical Oxygen Demand (mg.L-1)					
	P01	P02	P03	P04	P05	P06
T01	0.50 aC	1.49 aBC	4.40 aA	3.95 aA	2.17 aB	2.25 abB
T02	0.21 aB	1.52 aA	1.65 cA	1.59 bA	1.37 abA	2.49 aA
T03	0.15 aD	1.54 aB	3.32 bA	3.11 aA	1.31 abB	1.33 bcB
T04	0.02 aA	0.97 aA	0.94 cA	0.65 bA	0.73 bA	0.88 cA

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

The drop in BOD associated to the absence of precipitation allows to conclude that there was no particle transport to the bed of the water course. According to Basso et al. (2012) the particles carried by the surface runoff are composed of organic material, which can increase the BOD values, especially in the rainy periods.

Besides the seasonality, there was an effect related to the land uses in the drainage areas, since P01 and P02 presented their BOD lower than the concentrations found in P03 and P04. Among the aforementioned areas, there is a change of land-use that promotes the waterproofing of the soil, such as agricultural and pasture areas, which make it vulnerable to intemperic processes, and to the respective particle transport to the riverbed in rainy periods. Despite the observed facts, it is verified the compliance with the current legislation, which defines the maximum of 5.0 mg.L$^{-1.}$

Table 5. Total Dissolved Solids analysis regarding to spatiotemporal factors.

	Total Dissolved Solids (mg.L-1)					
	P01	P02	P03	P04	P05	P06
T01	133.33 aC	180.00 aC	386.67 aA	206.67 aBC	233.33 aBC	313.33 aAB
T02	226.27 aAB	151.33 aAB	266.67 bA	126.67 abB	126.67 abB	166.67 bAB
T03	133.33 aA	120.00 aA	153.33 cA	26.67 bcA	86.67 bcA	100.00 bcA
T04	146.67 aA	73.33 aAB	66.67 cAB	6.67 cB	0.00 cB	0.00 cB

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

Regarding total solids (Table 5), there is a statistically significant effect promoted by both seasonality and land-use, in agreement with the studies that have indicated the influence of the infiltration rates on the quality of the water coming from surface runoff (Kemerich et al., 2013). This finding corroborates the higher concentration of total solids in the headwater area, since the infiltration of the precipitated water is lower due to the high resistance to penetration, promoting a higher solids drift through the runoff.

The precipitation observed in T03 (April) was not enough to promote the transport of particles to the stream bed. The increase in concentrations from P03 (from T01 to T03) may be due to the increase of 41.8% in permeable areas without adequate protection of the watercourse, as well as to the launching of effluent of the commercial venture in the vicinity.

Table 6. Turbidity analysis regarding to spatiotemporal factors.

	Turbidity (UNT)					
	P01	P02	P03	P04	P05	P06
T01	0.02 aC	0.66 aC	11.64 cA	13.77 bA	4.77 bB	4.86 aBC
T02	0.02 aD	3.91 aC	24.35 abB	34.40 aA	26.80 aB	31.37 aA
T03	0.02 aD	0.66 aD	26.83 aA	10.49 bB	5.76 bC	6.83 bBC
T04	0.02 aB	0.93 aB	21.66 bA	4.22 cB	4.43 bB	4.53 bB

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

Souza and Gastaldini (2014) found that river basins with predominant agricultural areas, and with low incidence of native forests, are more susceptible to changes in total solids concentrations and turbidity. In Table 6, it can be observed that in P01 and P02 there was no significant change in turbidity as a function of seasonality, in contrast to P03 onwards, with the highest concentration in T02. Thus, seasonality has a significant effect on the turbidity values, in consonance with observations from Göransson et al. (2013), and Bhutiani and Khanna (2007).

Von Sperling (2007) relates the increase in turbidity to the throwing of domestic and industrial effluents, which corroborates the increase observed in the months of October (T01), April (T02), and July (T04) in P03, since it receives the effluent from a large shopping mall located in its drainage area. However, all

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 December 2022 doi:10.20944/preprints202212.0047.v1

samples comply with the applicable law, which determines the maximum value of 100 UNT, to maintenance a good quality in water bodies of the Class II.

Table 7. pH analysis regarding to spatiotemporal factors.

	pH					
	P01	P02	P03	P04	P05	P06
T01	6.04 bC	6.86 bB	7.51 aA	7.71 aA	7.61 aA	7.27 aAB
T02	6.09 bB	6.82 bcA	7.08 aA	7.37 aA	7.26 aA	7.19 aA
T03	6.72 aA	6.30 cA	6.41 bA	6.19 bA	6.23 bA	6.35 bA
T04	7.11 aA	7.42 aA	7.58 aA	7.71 aA	7.59 aA	7.65 aA

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

Regarding pH (Table 7), it is verified that in July (T04) all the points sampled were significantly higher, indicating that in the absence of precipitation, the water presents more basic characteristics. No significant changes were observed in terms of spatial distribution, except for October (T01) and January (T02), which presented lower values in P01, which has a 100% urbanized drainage area. It was not observed the same relation seen by Lima (2001), who found that in basins with drainage areas occupied by agriculture the pH of the water is slightly more acidic. Nevertheless, Longo et al. (2012, 2013) indicated changes in physical and chemical parameters of the soil, as anthropic effect in the micro-basin under analysis. It can be observed that in P01 and P02 the values found were slightly lower, indicating that between the subsequent points (P02 and P03) there is an effect of land use raising the pH, which may be related to the presence of a large commercial enterprise (which discharges its treated effluent into the waters of the stream).

Soon afterwards an agricultural area is observed, in which there is commonly the application of fertilizers and pH correcting substances, corroborating the variation observed. It is also verified that all points presented values within the limit established by the law, with values between 6 and 9.

Table 8. Total Nitrogen analysis regarding to spatiotemporal factors.

	Total Nitrogen (mg.L-1)					
	P01	P02	P03	P04	P05	P06
T01	0.54 aB	15.62 aB	89.22 bA	11.45 bB	22.71 aB	24.93 abB
T02	0.43 aA	17.32 aA	30.17 cA	15.09 bA	30.49 aA	19.75 abA
T03	0.27 aD	44.13 aC	227.95 aA	91.76 aB	39.06 aC	7.95 bCD
T04	0.00 aC	49.33 aAB	82.71 bA	79.86 aA	36.52 aBC	44.94 aAB

Averages followed by the same lowercase letter do not differ significantly regarding seasonal effect; Averages followed by the same capital letter do not differ significantly regarding spatial effect. Tukey test with 5% significance.

The increase in nitrogen concentrations, observed in Table 8, may be associated to the occurrence of agricultural areas, as well as the precipitation that generates surface runoff and, consequently, favors the transport of particles to the riverbed. Among the evaluated points, P03 presented significant alteration of this parameter and, as presented in Table 1, it receives a contribution from an area lacking forest vegetation and with larger proportions destined to the agricultural crop.

Total nitrogen was high in the samplings of April (T03) and July (T04) in P04, which is related to the fact that it is a lentic environment. As it is a lagoon, when there is absence or reduction of precipitation the circulation of water is also smaller, favoring the high concentration of this nutrient. The legislation defines the boundary concentrations according to the pH ranges. Samples with pH ≤ 7.5 must comply with a maximum of 3.7 mg / L, while for 7.5 <pH ≤ 8.0 the

established maximum is 2.0 mg / L, so that only the main headwater of Stones River meets the established.

Table 9. Total phosphorus analysis regarding to spatiotemporal factors.

	Total phosphorus (mg.L-1)					
	P01	P02	P03	P04	P05	P06
T01	0.0198	0.0270	0.0544	0.0544	0.0383	0.0431
T02	0.0047	0.0183	0.0273	0.0210	0.0233	0.0387
T03	0.0087	0.0290	0.0420	0.0317	0.0237	0.0300
T04	0.0153	0.0153	0.0160	0.0167	0.0157	0.0150

The comparison test was not applied because the interaction F was not significant.

For the concentrations of total phosphorus there was no statistically significant difference between the mean values by the Tukey test, but there is evidence of seasonal interference, since in July (T04) the concentrations remained below the other analyzed dates. There was an increase in the concentrations between P01 and P03 (P01 <P02 <P03), thus indicating spatial interference with water quality. At point 1, where the area is completely urbanized, the phosphorus concentration is low (river headwater). In point 2, where a little of vegetation (less than 10%) is inserted, there is an increase. In turn, in point 3 it is noticed an increase even more evident, which may affect bigger vegetation areas (approximately 40%). The legislation is not met in the January (T02) sampling in P03, which may be due to the increase in permeable areas without riparian vegetation. In P04 the samplings of October (T01) and April (T03) did not present evident relations. Only the samples collected in the headwater of Stones River meet the resolution.

Conclusion

From the analysis of the physical-chemical parameters, it can be concluded that, despite advances in the Brazilian legal framework, land use has still significantly affected water quality in a peri-urban river basin, at metropolitan region of southeastern Brazil. Therefore, the protection of water resource quality requires effective compliance with the rules for controlling land-use and occupation, demanding measures capable of monitoring their application, as well as guiding land use through more sustainable practices. For further advances in future studies, the recognition of patterns of the effects of land-use on water quality, at this metropolitan region, can be deepened with the use of multivariate screening techniques combined with computational intelligence, which requires the expansion of the database.

Author Contributions

Conceptualization, Adriano Bressane, Admilson Ribeiro and Regina Longo; Data curation, Anna Loureiro, Raissa Gomes and Rogério Negri; Formal analysis, Adriano Bressane, Anna Loureiro, Raissa Gomes, Regina Longo and Rogério Negri; Investigation, Anna Loureiro, Admilson Ribeiro and Regina Longo; Methodology, Adriano Bressane and Raissa Gomes; Project administration, Admilson Ribeiro; Software, Raissa Gomes and Rogério Negri; Writing – original draft, Adriano Bressane, Anna Loureiro, Raissa Gomes, Admilson Ribeiro, Regina Longo and Rogério Negri.

References

American Public Health Association. APHA. 2005. Standard Methods for the Examination of Water and Wastewater. 21 ed. Washington.

Basso, l. A.; Moreira, l. G. R.; Pizzato, F. 2012. The influence of precipitation on the concentration and load of solids in urban streams: the case of the Dilúvio stream, Porto Alegre-RS. Geosul, 26(52): 145-163.

Bhutiani, R.; Khanna, D. 2007. Ecological study of river Suswa: modeling DO and BOD. Environ. Monitor. Assess: 125: 183–195.

Bressane, A.; Ribeiro, A.I.; Medeiro. G.A. 2016. Environmental reclamation as strategy for sustainability. Veredas, 13(27): 109-133.

Kemerich, P. D.C.; Martins, S. R.; Kobiyama, M.; Santi, A. L. FLORES, E. B.; Borba, W. F; Fernandes, G. D.; Cherubin, M. R. 2013. Water quality originated from the superficial outflow simulated in a hydrographic bay. Ciência e Natura, 35(2): 136-151.

De-Carli, B. P.; Souza, J. C.; Souza, J. A. P.; Shoegima, T. F.; Barreiro, M. P. R.; Dutra, A. C.; Medeiros, G. A.; Ribeiro, A. I.; Bressane, A. 2019. Relationship Between Land Use and Water Quality in a Subtropical River Basin. Journal of Social, Technological and Environmental Science, 7(3): 245-261.

Etto, T.L., Longo, R.M., Arruda, D.R., Invenzioni, R., Cereda Junior, A. 2013. Landscape ecology of the forest fragments of Stones River watershed - Campinas, São Paulo State – Campinas/SP. Revista Árvore, 37:1063–1071.

Göransson, G.; Larson, M.; Bendz, D. 2013. Variation in turbidity with precipitation and flow in a regulated river system–River Göta Älv, SW Sweden. Hydrology and Earth System Sciences, 14(7): 2529-2542.

Lee, S. W., Hwang, S. J., Lee, S. B., Hwang, H. S.; Sung, H. C. 2009. Landscape ecological approach to the relationships of land use patterns in watersheds to water quality characteristics. Landscape and Urban Planning, 92(2): 80-89.

Lima, E. B. N. R. 2001. Integrated model for the water quality management of Cuiabá river basin. Phd Thesis. Rio de Janeiro: UFRJ.

Longo, R.M.; Reis, M.S.; Yamaguchi, C.S.; Demamboro, A.C.; Bettine, S.C.; Ribeiro, A.I.; Medeiros, G.S. 2012. Indicators of soil degradation in urban forests: physical and chemical parameters. Transactions on Ecology and the Environment ,162: 497–506.

Longo, R.M.; Zangirolami, G.F.; Yamaguchi, C.S.; Demamboro, A.C.; Bettine, S. C.; Ribeiro, A.I. 2013. Impacts of agricultural activities in remaining forest: Campinas/SP, Brazil. Transactions on Ecology and the Environment, 170:15-23.

Mehdi, B.; Lehner, B.; Gombault, C.; Michaud, A.; Beaudin, I., Sottile, M. F.; Blondlot, A. 2015. Simulated impacts of climate change and agricultural land use change on surface water quality with and without adaptation management strategies. Agriculture, Ecosystems & Environment, 213:47-60.

Mello, K,; Taniwaki, R.H.; Paula, F.R.; Valente, R.A.; Randhir, T.O.; Macedo, D.R.; Leal, C.G.; Rodrigues, C.B.; Hughes, R.M. 2020. Multiscale land use impacts on water quality: Assessment, planning, and future perspectives in Brazil. Journal of Environmental Management, 270: e110879.

Mello, K.; Valente, R.A.; Randhir, T.O.; dos Santos, A.C.A.; Vettorazzi, C.A. 2018. Effects of land use and land cover on water quality of low-order streams in Southeastern Brazil: Watershed versus riparian zone. Catena, 167: 130-138.

Ngoye, E.; Machiwa, J. F. 2004. The influence of land-use patterns in the Ruvu river watershed on water quality in the river system. Physics and Chemistry of the Earth, 29(15): 1161-1166.

 doi:10.20944/preprints202212.0047.v1

National Health Foundation. NHF. 2009. Guide for Collection and Preservation of Samples. London: NHF.

Reis, J. T. 2012. Environmental fragility assessment in an urban watershed for subsidizing an integrated environmental impact assessment. Ph.D. Thesis. Porto Alegre: UFRGS.

Sanders, E. C.; Yuan, Y.; Pitchford, A. 2013. Fecal coliform and E. coli concentrations in effluent-dominated streams of the Upper Santa Cruz Watershed. Water, 5(1): 243-261.

Souza, M. M.; GastaldinI, M. C. C. 2014. Water quality assessment in watersheds with different anthropogenic impacts. Eng. sanit. ambient, 19(3): 263-274.

Ullah, K.A.; Jiang, J.; Wang, P. 2018. Land use impacts on surface water quality by statistical approaches. Global J. Environ. Sci. Manage.,4(2): 231-250.

Von Sperling, M. 2007. Introduction to water quality and sewage treatment. 3 ed. Belo Horizonte: DESA.

Tu, J. 2011. Spatial variations in the relationships between land use and water quality across an urbanization gradient in the watersheds of northern Georgia, USA. Environmental management, 51(1): 1-17.