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Organic farm does not improve neither soil, or water quality in rural watersheds from southeastern Brazil

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ABSTRACT

This study was conducted in a rural region where there are conventional and organic farms, the agricultural production includes more than 20 million people, and the effect on environmental quality is still poorly known in terms of indicators. Our objectives were: (1) compare soils attributes to reference areas, (2) verifying if cultivated areas under different farm systems presented differences in the soils attributes, (3) evaluate the attributes of quality water of watersheds and comparing the results with limiting values established by environmental legislation, and (4) analyze the values considering three criterion: watersheds, climatic season, and region of the landscapes. The study was conducted in two rural watersheds that have similar biophysical features and located in the Ibiúna municipality, São Paulo State, Brazil. However, one watershed encompasses farms where landowners largely use conventional agricultural systems. In the other watershed approximately 25% of the farms there are using an organic farm system. In the two watersheds soil samples were collected in sites covered with natural forest and in sites with agriculture (one watershed being organic and other being conventional). The attributes analyzed were soil bulk density (BD), concentrations of Carbon (C) and Nitrogen (N), C:N ratio, C Management Index, and the abundance of ^{13}C and ^{15}N in the soil organic matter. Water attributes were analyzed onsite or in laboratory after analysis of samples. Analyses included: air and water temperature, pH, dissolved oxygen, salinity, total of dissolved solids, total solids, electric conductivity, turbidity, total chloride, nitrate, total phosphorus and potassium. Regarding the soil attributes our database revealed that (1) the soils from cultivated sites of both watersheds presented significant differences from their respective forested areas, (2) Soil attributes are of equal quality in both farm systems. Concerning water attributes: (1) almost all attributes presented values better than the limiting values stipulated by Brazilian legislation; (2) the watersheds did not present significant differences of most of the attributes; (3) in the criteria climatic season data showed some significant differences. The data showed that the soils from the areas used for agricultural ends present belief that significantly worse soil quality in comparison to soils from sites still covered with natural forest. Neither the land cover nor farming system are altering the superficial water quality of the studied watershed and this appears to be related to the extensive percentage of natural remaining vegetation that still exists in both watersheds. The seasonality is an important force that drives the quality characteristics of the water. We highlight that the principles of organic agriculture should be practiced more efficiently and influences such as deforestation should be rigorously avoided.

1. Introduction

Integrated assessment of natural resources is of paramount importance anyplace worldwide, once human well-being depends on the quality of natural resources (UNEP (United Nations

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Environmental Program), 2011). It is highly important in establishing strong and coherent institutional arrangements that are needed to ensure the efficient collection, storage, analysis and summary of data and the availability of data, for instance of soil and water quality, to potential users. One of the difficulties in carry out integrated studies is due the existence of interaction and response in multiple scales within and between natural subsystems (Sykes et al., 2001). Consequently, studies integrating databases regarding soil and water have not been so common. The accomplishments of a watershed management programs are dependent on survey data and analysis in the different compartments and verification of the influence among each other.

In the Brazilian southeastern region we have the Ibiúna municipality, sited approximately 80 km west far from São Paulo Capital City. Ibiúna is an important tourist region and also encompasses important areas used for agriculture. The São Paulo's metropolitan region encompasses the Capital City São Paulo and also 38 municipalities, and has a population of approximately 21 million people. This region is the main consumer center of most of the agricultural products produced in Ibiúna. In Ibiúna there are two adjacent watersheds that jointly constitute an interesting scenario for conducting a comparative analysis of attributes of soil and water, because on the one hand, such watersheds have similar natural characteristics among them, and the other hand, in one of the watersheds organic farming is practiced there, and in the other conventional agriculture is practiced. Hence, this scenario is suited for developing an integrative study considering responses of the soil and water quality attributes according to land cover and land use.

1.1. Soil and water attributes related with rural land use

Soils play a key role in the definition of sustainable land management since they represent the basis of food production (Fliessbach et al., 2007). A fertile soil provides essential nutrients for crop plant growth, supports a diverse and active biotic community, exhibits a typical soil structure, and allows for undisturbed decomposition of organic materials (Mader et al., 2002). The ecosystem services provided by the soil are usually constituted by a set of chemical, physical and biological attributes and commonly indicate the quality of soil. On its turn, isotopic abundances could be a powerful tool to elucidate differences in ecosystem functioning and driving mechanisms of element cycling in the different land cover situations, like forest-covered and agricultural sites, as well as different land uses, like organic and conventional management systems (Choi et al., 2003; Klaus et al., 2013).

On the other hand, soils exert a fundamental influence on water attributes. How we handle the soil and what we deposit on it determine, in part, the level of treatment required to protect our water supplies. Agriculture is estimated to be responsible for 70% of nitrate and 30–50% of phosphorus pollution (Kay et al., 2012) and the land use is responsible for a major amount of total solids delivered to water bodies (Welch and Jacoby, 2004). This shows why an efficient soil management and planned land cover help protect water quality.

The concept of what is rural has an exceptional range of variations worldwide. In this study, we consider the concept of proposed by Brazilian Institute for Geography and Statistics (www.ibge.gov.br): a rural area is an area that is located externally to a town. In rural areas there are many kinds of land cover, leading to different forms of soil management and with different amounts and intensities of environmental impacts, including loss in quality to both soil and stream water.

1.2. Organic and conventional vegetable farms

Agriculture is a kind of human activity developed to produce goods of value to people. Farmers commonly use a set of approved agronomic practices in order to get the best agricultural yield from the field. Some of the activities include, but is not limited to: genetic melioration of the cultivars, soil management techniques, including several kinds of fertilization and tillage, pest control, water management, among others. Some agronomic practices are included in the concept called "conventional farm system", as the adoption of monocultural agroecosystems, use of several types of pesticides, mineral fertilizers and other practices that admittedly are degrading both for environment and human health. However, it is well known that a large number of farms worldwide are still using this type of farming system.

Conversely, since the last decades, new agronomic practices have been developed, aiming to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings (Naturland, 2014; Seufert et al., 2012). Due to the capacity of producing good crop yields with minimal impacts on environmental features, many people believe that "organic farming systems" that consider different practices and crop rotations and/or use of organic fertilizers in adequate amount and quality might represent a realistic alternative to conventional farming systems (Mäder et al., 2002). However, in several situations, especially in areas where it is not usual to work with consultants, groups of farmers with a commercially interest in cash crops who work without any inputs are certified organic and able to sell for a premium price without signification changes in agricultural practice (Brul, 2012).

Organic agriculture has as one of the principal principles sustaining and improvement of the soil (Naturland, 2014). However, while some analyzes regarding the effectiveness of using organic-based agronomic techniques in order to actually promote environmental ameliorations has generated highly diversified results, where some studies showing effectiveness (Winqvist et al., 2012), and others showing that the performance is not significantly different (Hokazono and Hayashi, 2012). For example, albeit there is some evidence that concentrations of Carbon (C) in the soil are greater in soils managed organically than in those from integrated or conventional farming, other studies have not found such differences (Marinari et al., 2006; Mondelaers et al., 2009; Parras-Alcántara et al., 2014). If soils from organic farms have been practiced on nutrient limited soil they do not respond as strongly as production from irrigation or conventional systems. On the other hand, better water-holding capacity and water infiltration rates have produced greater yields than conventional systems under drought conditions and excessive rainfall (Seufert et al., 2012).

Furthermore, while studies involving soil-related attributes with organic farming systems are abundant, studies relating surface water-related attributes and organic farming systems are less common, especially in Brazil (Takino and Maier, 1997). Some researchers suggest that "organic farmscapes" might reduce the amounts of nitrogen (N) and phosphorus (P) transported from the soil surface due the reduction of volume of runoff, and conversely, environmental problems most commonly found on organic farms result from mismanaging manure applications or soil incorporation of green-manure crops, or from improper storage of manure or compost (Bellows, 2002).

One of the features that is responsible, is the high variability of performance of organic farm systems is regarding the time of adoption of organic-based farm system in the rural property (Marinari et al., 2006; Assis and Romeiro, 2007). Another factor is the differentiated use of organic-based agronomic techniques and organic fertilizers among sites. Because of these inconsistent

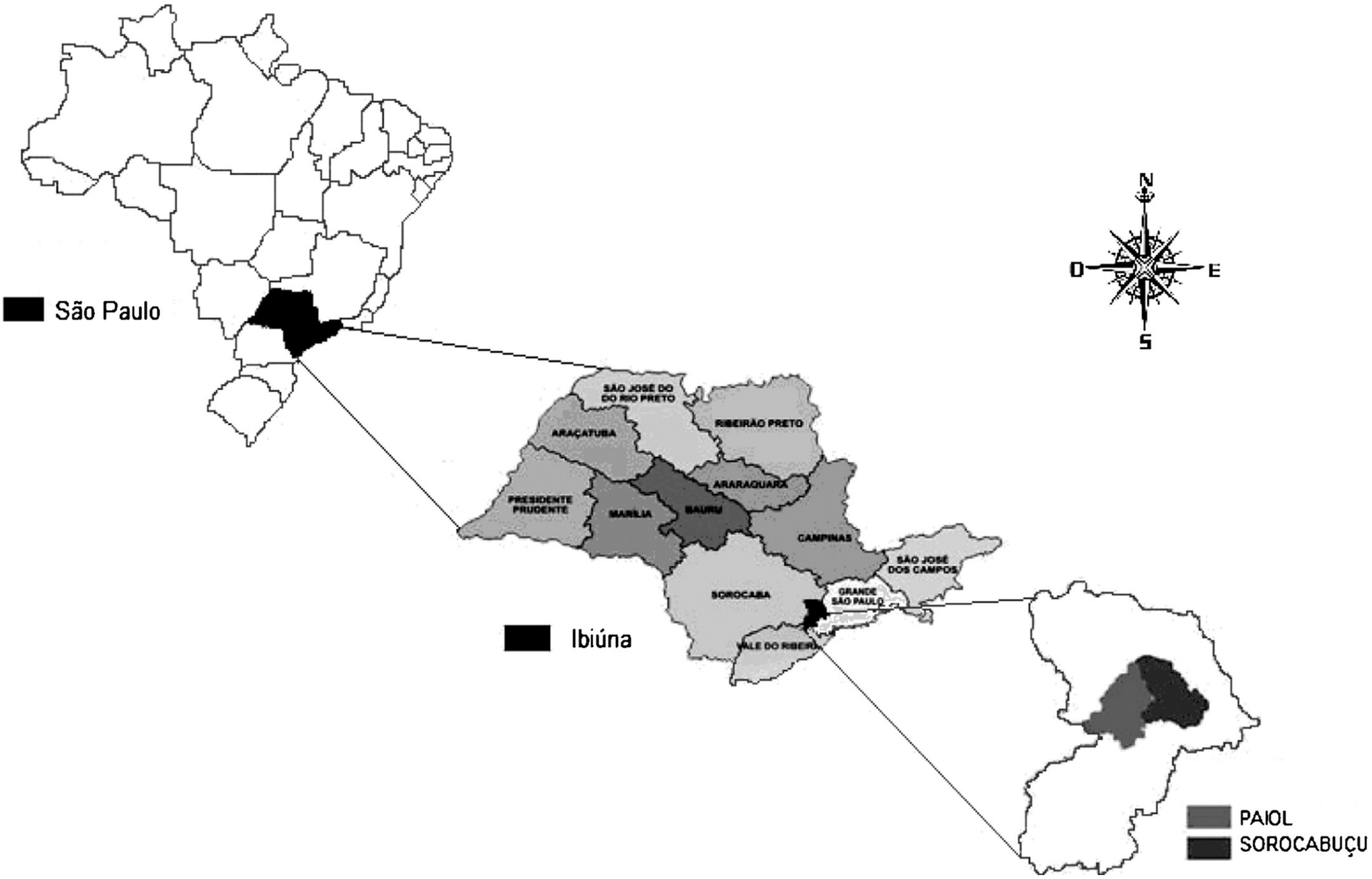

Fig. 1. Location of Ibiúna in the São Paulo State (center) and the two watersheds.

findings, advantages and disadvantages of the organic farming system vs. integrated or conventional production are hotly debated (Gattinger et al., 2012).

This study was conducted with the aim to compare soil-related and water-related features in two rural watersheds located in rural area of Ibiúna Municipality. We considering two hypotheses: (a) the land cover significantly changes the topsoil attributes and (b) the soil management systems adopted in the agricultural areas of study areas are enough to cause significant alterations in the investigated soil and water attributes.

2. Location and environmental features of the study area

The study was carried out in two watersheds fully included in the geopolitical boundaries of the Ibiúna Municipality, São Paulo State, Brazil (Fig. 1). The geographical coordinates are 23°35′50″ and 24°01′14″ of South Latitude, and 46°59′05″ and 47°23′17″ of West Longitude, with approximately 930 meters of mean altitude. From the 71,157 inhabitants of Ibiúna, 66.4% live in the rural areas (IBGE (Brazilian Institute for Geography and Statistic), 2013). The two studied watersheds are named Paiol (PA) and Sorocabuçú (SO), respectively. Moreover, in terms of river network, such watersheds are tributaries of the Itupararanga reservoir that provides drink water for all municipalities of the Sorocaba region, containing approximately 800,000 people.

The watersheds are neighboring each other and the climatic features are considered spatially uniform (Manfré et al., 2013). The climate is subtropical and the region has an annual mean temperature of 19.3 °C and the mean rainfall annual height of 1428 mm. Both watersheds have a similar occurrence of the proportions of the land cover categories, and in both the predominant use is remnant natural forest vegetation (Table 1).

The soil class Ferralsols are the major class occurring in both watersheds (78.9%in SO and 70.1% in PA). Cambisols also occur (21.1%in SO and 23.4% in PA). In PA watershed also includes Lithosols (6.5%). Sand is the predominant granulometric fraction (mean value of 52.0%), followed by clay (29.0%) and silt (18.0%). In some forest fragments vegetation is mainly secondary and it is in an early succession stage (Manfré et al., 2011a).

In the two watersheds the land use is predominantly for rural purposes, and the agricultural production are the same (Manfré et al., 2011a; Valarini et al., 2011) with approximately 60 plant species being cultivated (COAGRI (Cooperative of Organic Farmers and Solidarity Ibiúna), 2013). The main products grown in both watersheds are greens and cooking herbs: cabbage, chicory, chives, carrot, chard, chayote, lettuce, and parsley. Usually three crops are cultivated per year, mainly leafy vegetables (Oelofse et al., 2010).

According to the Municipal Agricultural Secretary of Ibiúna Municipality and complementary information obtained from Google time-lapse system (https://earthengine.google.org), both

Table 1
Percentages of occurrence of each land cover category for the two watersheds.

Land cover class	PA	SO
Agriculture	10.0	8.7
Bare soil	14.0	15.6
Natural Remnant Vegetation	38.8	38.5
Pasture	15.4	16.4
Reforested	19.2	18.6
Water bodies	2.6	2.2

Source: Manfré et al. (2011a).

watersheds have been used for agricultural at least since 1970's, when conventional agriculture was practiced in all rural properties.

However, while in PA the farmers continued to practice the conventional agriculture to the present, in SO some farmers have adopted some organic farm techniques since approximately fifteen years ago (according to information provided by Municipal Agricultural Secretary of Ibiúna Municipality). Nowadays, the total area of the organic farmers in the SO watershed represents approximately 25% of the entire watershed and in none farm that currently is organic farm the land was abruptly shifted from forest to organic agriculture, meaning that all farms currently labeled as organics were previously conventional farms.

Crop rotation is an agricultural practice that is employed under specific interests in the rural properties along the study areas (explained ahead). In addition, considering that intercropping includes the growing of two or more cash crops together (Mohler and Johnson, 2009) such management practice does not occur along the study areas (either conventional or organic). The organic farms of the study area are exclusively for proposes of vegetal production and certified by one of the three main certifies systems (BAM (Federal Brazilian Ministry of Agriculture), 2013). According to information found in Oelofse et al. (2011) and provided by Municipal Secretary of Agriculture of Ibiuna, the main soil amendments used are composts (manure and mixed).

3. Procedures

3.1. Soil sampling and analyzes

Intact soil cores were collected from each of 60 sampling points at the 0–20 cm depth, using a steel ring. Just to the side of where the core was collected an additional sample was taken with a Dutch auger. Samples were collected during October and December of 2009. For each land cover class, soil samples were collected in one core for each site in order to avoid influence of edge effects on the characteristics of the investigated attributes. Thirty samples were collected in each watershed. In PA, 19 were collected from cultivated sites and 11 were collected from forested sites. For SO, watershed 20 were collected from cultivated sites and 10 were collected from forested sites. For both watersheds, data obtained of samples collected in forested sites were considered as reference for this study.

In the laboratory of Campus Sorocaba—UNESP, all samples were oven-dried (80 °C). The auger samples were separated into two homogeneous subsamples. The first one was passed through a 2.00 mm sieve and the fraction <2.00 mm was used for determination of the Management C Index (MCI) (Blair et al., 1995), using the following equation:

$$\mathrm{MCI} = \mathrm{CPI} \times \mathrm{LI} \times 100 \tag{1}$$

where: CPI—C pool index; LI—lability index.

The CPI is obtained dividing the C concentration of soil from the cultivated systems by C concentration of soil from natural remnant forest area.

For lability index we divided the amount of the labile organic fraction of the sample from cultivated sites by labile organic fraction of the sample from reference area. For each land cover (agriculture and forest), the proportion of labile organic C was determined by division of labile fraction and non labile fraction.

For determination of amount of labile C in each subsample, we took 0.3 g of sample (<2.00 mm) and transferred it to an Erlenmeyer flask of 250 mL. In this flask we added 10 mL of potassium dichromate ($K_2Cr_2O_7$ 0.167 mol/L) and 3 mL de H_2SO_4. No external source of heating was used. The excess of $K_2Cr_2O_7$ was measured volumetrically using a Mohr's salt solution ($Fe(NH_4)^2(SO_4)^2 \cdot 6H_2O$—0.4 mol/L (Carreira, 2005). We used phenanthroline as an indicator. The percentage of labile fraction was determined by the following equation (Rangel et al., 2008):

$$\%\mathrm{C} = \left(\frac{(\mathrm{Bl}_m - \mathrm{Sp}_m) \times M \times 3)}{m}\right) \times 100 \tag{2}$$

where: Bl_m—volume of the titrated solution spent for titrate the blank sample (ml), Sp_m—volume of the titrated solution spent for titrate a soil sample (ml), m—mass of the soil sample used in the process, M—molarity of the Mohr's salt solution, in moles/l, 3—factor of conversion of the oxidation level of C, in g/mol.

The second subsample of each auger sample was passed through a 0.35 mm sieve and the fraction <0.35 mm was submitted to analysis of concentrations of C and N and the abundance of ^{13}C and ^{15}N determined. These analyses were performed in the *Centro de Energia Nuclear na Agricultura of the São Paulo University* (CENA-USP, Piracicaba-SP, Brazil), using a gas chromatography after sample burning in an oxidizing medium with an elemental analyzer (CE CHN-1110, Milan, Italy) conjugated to an isotopic ratio mass spectrometer (Thermo Scientific Delta Plus, Bremen, Germany). The isotopic signature was determined using the following equation:

$$\delta^{13}\mathrm{C}\,(\mathrm{or}\,\delta^{15}\mathrm{N}) = \left[\frac{(R_{\mathrm{sa}} - R_{\mathrm{st}})}{R_{\mathrm{st}}}\right] \times 1000 \tag{3}$$

where Rsa and Rst are the ^{13}C/^{12}C (or ^{15}N/^{14}N) is the ratio of samples and standard, respectively. For ^{13}C/^{12}C, the reference material is the carbonate from a fossil belemnite from the Pee Dee Formation (Farquhar et al., 1989). For ^{15}N/^{14}N, the standard is atmospheric N_2 (Robinson, 2001).

Using the ring samples, we determined the bulk density (BD) by dividing the dry mass of sample by its respective volume (EMBRAPA (Brazilian Enterprise of Agricultural Research), 1997).

Soil Carbon stock was determined using the following equation (Desjardins et al., 2004; Galdos et al., 2009):

$$\mathrm{SCS} = \mathrm{C} \times \mathrm{BD} \times \mathrm{L} \tag{4}$$

where: SCS (soil carbon stock, in Mg/ha), C (carbon concentration, in g/kg), BD (soil bulk density, in g/cm^{-3}), L (thickness, in cm–for this study: 20 cm). Gravels did not occur in our samples, so no corrections were needed. C_{st} values were corrected for soil mass taken into account the descriptions of Ellert and Bettany (1995) and Poeplau et al. (2011) for the pair site comparisons.

Data regarding C and N concentrations for our study areas were firstly presented in Manfré et al. (2011a). Here these data are considered in order to support an integrated discussion about the abundance of ^{13}C and ^{15}N and for using in the CMI estimative. Furthermore, data regarding C stock were firstly presented in Manfré et al. (2011b), but in this paper the authors did not consider the criteria of mass correction, which was done here.

3.2. Water attributes

In each watershed, three sampling points were established, with one site in the upper region of the watershed, one the in the middle part and one in the lower part. Two campaigns of collections were carried out: one in October of 2009 and other in March of 2010. In each season, all six sampling points were visited in the same day. In each sampling point, the attributes were surveyed according to procedures described in Table 2. When feasible, surveyed data were compared with values established by Brazilian environmental legislation (CONAMA (Brazilian National Bureau for Environment), 2005). The Trophic State Index was calculated using data of total phosphorus using Equation 5, showed in Lamparelli (2004) and currently considered by São Paulo State Environmental

Table 2
Description of the procedures for measuring water attributes.

Variable	Procedure
Air temperature	Measured directly in the air using a digital thermometer and avoiding direct exposure of the device to sun light and wind
Water temperature	A sample of 1 liter of water was carefully collected in the superficial, central part of the cross section of the river channel using a small, plastic bucked. Just after collection, an Oakton Multiparameter equipment model PCS Test 35, previously calibrated, was immediately inserted in the sample in order to quantify the five attributes cited in left column
pH	
Total of dissolved solids	
Salinity	
Electric conductivity	
Dissolved oxygen	Using the same sample of water collected according the procedure described above an dissolved oxygen meter model Instrutherm MO-910, previously calibrated was also immediately inserted in the recipient in order to measure the concentration of dissolved oxygen in the water
Total solids	In the same sampling point described above, another sample of water was collected. A volume of two liters of sample was collected in a PVC flask and transported to laboratory of Campus Sorocaba - UNESP. For determination of total solids the PVC flask was firstly gently shaken, and after a subsample of 100 mL was taken and oven-dried (105 °C) and after the evaporation the mass of total solids was measured (APHA, 1999)
Turbidity total chloride nitrate total phosphorus potassium	Another subsample was taken and used for quantifying the attributes described in the left column. We used a spectrophotometer Hach model DR2800. The chemical reagents and wave length calibration were previously established accordingly to the instructions of the user's manual of the equipment

Company (CETESB) in monitoring activities of rivers of São Paulo State.

$$\mathrm{TSI} = 10 \times \left(6 - \left(\frac{(0.42 - 0.36 \times (\ln \mathrm{T\,Ph}))}{\ln 2}\right)\right) - 20 \qquad (5)$$

where: TSI—trophic state index (dimensionless); T Ph—total phosphorus (mg/L); ln—natural logarithm.

3.3. Statistical analyses

The database was tested using a non-parametric analysis of variance (Krukal–Wallis test) in order to check for significant differences among the established criterion for soil and water attributes. For soil attributes, the criterions for comparison were: land cover category within the watershed (forest and agriculture) and farming system among the watersheds. For water attributes, the criterions were: watershed, the landscape position of the sampling point (upper (or shoulder), middle (or backslope) and low (footslope) part of the watershed) and the season.

Spearman's correlation test was carried out using the attributes for both soil and water. Furthermore, data were also submitted to a discriminant analysis in order to show the level of distinction among the sampling points of each one of the land cover categories of the soil attributes. Principal component analysis was also carried out using the database of water attributes.

4. Results

4.1. Soil attributes

Soils from agricultural sites from both watersheds had high similarity among them for all attributes studied, permitting us to affirm, beforehand, which independent of the farm system, that the soil characteristics from organic farms were not better than the cultivated soils from conventional farms. However, cultivated soils from both farm systems are significantly altered in relation to the respective reference forested soil areas.

First, observing the total database, we observed that all soil samples from studied areas present values of BD considered low, and the soils of the regions can be considered light (Primavesi, 1987). All samples located in the 1st quartile (presented in Table 3) are from forested sites. However, samples from cultivated soils of both watersheds presented a significant amount of compression in relation of their respective reference areas (Tables 4 and 5). The farming system did not have an influence significantly on the BD (Fig. 2). Taken into account the mean values, in SO, the BD value is 45% and for PA the BD is 53% greater than the respective forested areas.

The C concentration was the variable that presented greatest overall coefficient of variation, and the mean value was notably greater than the median (Table 3). Thirty eight samples had a value of C concentration lesser than the overall mean, being four samples from forested sites (three from PA and one from SO). Independent of the land cover category and/or the farming system, the correlation value observed between the values as a whole of C and N concentrations was significant ($r = 0.98$, $P < 0.001$) and such a high correlation confirms the tendency usually reported on literature. Comparing cultivated and forested sites, in both watersheds we observed significant differences among the land cover categories. Cultivated soils from presented a mean value of C concentration 48% and 57% lesser in the PA and SO watersheds, respectively, in relation to respective forested sites (Tables 4 and 5). Differences between the mean values of the two farm systems were less than 1.5 g/kg and were not significant (Fig. 2).

A similar situation was observed for C stock, were only three samples whose value were lesser than the overall mean are from forested sites (two from PA and one from SO). Correlation among C concentration and C stock was 0.98 (significant at $P < 0.001$), while the correlation among C stock and BD was also significant, although inversely ($r = -0.67$, $P < 0.001$). Cultivated soils of both watersheds are storing a little bit more than a half of C in relation of their

Table 3
Descriptive statistics for studied soil attributes considering all samples ($N = 60$).

Variable	Minimum	Maximum	Median	1st Q (25%)	3rd Q (75%)	Mean	CV (%)
Bulk Density (g/cm^3)	0.30	1.29	0.85	0.71	0.96	0.84	26.9
δ^{15}N (‰)	3.74	12.67	7.64	6.60	8.79	7.67	23.3
N (g/kg)	0.12	5.99	1.88	1.31	2.99	2.28	59.3
δ^{13}C (‰)	−28.46	−11.36	−23.06	−26.19	−21.09	−23.32	14.0
C (g/kg)	2.10	91.57	27.57	17.78	42.29	32.35	62.3
C stock (Mg/ha)	2.61	107.95	35.36	22.06	54.06	40.42	57.2
C:N ratio	11.62	18.34	14.15	13.03	15.10	14.20	10.8

1st Q—fist quartile; 3rd Q—third quartile; CV—coefficient of variation.

Table 4

Mean and coefficient of variation of the soil attributes according to land cover category of PA watershed. For each soil attribute, different letters mean difference statistically significant according to Kruskal Wallis test ($P < 0.05$).

Land cover and number of samples	Agriculture ($N = 19$)		Natural remnant vegetation ($N = 11$)	
Soil attributes	Mean	CV (%)	Mean	CV (%)
Bulk density (g/cm^3)	0.96a	21.0	0.66b	26.5
δ^{15}N (‰)	8.25a	12.1	6.08b	23.3
N (g/kg)	1.63a	52.8	3.35b	37.9
δ^{13}C (‰)	−21.36a	8.3	−26.95b	3.1
C (g/kg)	23.96a	67.3	45.90b	41.0
C stock (Mg/ha)	31.62a	67.0	60.58b	40.7
C:N ratio	14.27a	11.0	13.64b	9.5

respective pristine (Tables 4 and 5), reference areas and the difference among the farm systems was not significant (Fig. 2).

Overall mean value of δ^{13}C suggests the predominance of soil organic matter (SOM) originated by organic material from C_3 plants. Our study areas are situated in a region of Atlantic Rain Forest, which is a biome dominated by C_3 plants. The mean values obtained from forest sites of both watersheds confirm the large occurrence of C_3 plants. On the other hand, the main alteration in the δ^{13}C value of the SOM usually occurs when a forested, C_3 plants-dominated region is shifted by a new land cover type dominated by C_4 plants, usually grassy species. The indicator is that the SOM becomes more enriched of ^{13}C and the isotopic signature of C from SOM becomes less negative. For our study region, despite the cultivated soils are cultivated not exclusively with grassy species (for example sugarcane is not grown and corn is cultivated in small proportions in both watersheds), for both watersheds the values were significantly less negative than the forest-covered soils. The process of modification of isotopic signal of C from SOM usually takes several years to occur, and in agricultural sites, other additional factors in addition to the vegetation shifting might participate of the fractionation process of C.

Only three samples from forested sites presented value of δ^{15}N greater than the overall mean and all samples sited in the 4th quartile are from agricultural sites (Table 3). From the fourteen samples sited in the 4th quartile, nine of them were collected in sites from organic farms. In both watersheds the δ^{15}N mean values were significantly greater in cultivated than in forest-covered soils, but not significantly different between the farm systems.

Twenty two samples presented values of N concentration greater than the mean value. Only four samples from agricultural (two of each farm system) are sited in such group. Cultivated soils from both agricultural systems presented a mean value of this variable lesser than a half of the mean value of the respective reference sites. Soils from organic-related sites presented mean values slight greater than the overall mean, being not significantly different of the soils from conventional farms however.

The C:N ratio was the variable that presented the lowest coefficient of variation. As verified in the BD values, all samples presented values considered low, independently of the land cover or farm system. This reflects the kind of material that is deposited in the ground, naturally through anthropogenic activities and also reflecting the relatively advanced stage of decomposition of the organic material existent in the soil. Comparatively, only PA presented a significant difference between forest-covered and cultivated soils.

Both farming systems presented values of C management index (CMI) lesser than 100%, indicating quality of C was worse than the C of SOM from soils of respective forested areas (Table 6). Soils from cultivated sites of PA appeared be in a situation slightly better than in SO, because the final value CMI was greater. PA presented a value of C pool index greater than SO, however, the C in the SOM from cultivated soil of SO looks be a little bit different than in PA, because the values of lability and lability index are greater in soils of SO.

Result obtained through discriminant analysis demonstrates the situations of occurrence or absence of significant differences among the sites. The discriminant analysis revealed two distinct groups composed by samples from cultivated soils in another group constituted by samples from forested sites (Fig. 3). Within each group no distinction was confirmed neither among the forested regions of PA and SO, nor among the farming system. The errors of classification confirm the high similarity of the data of the soils from the two farming systems.

4.2. Water attributes

For all dates we observed that the river water was colder than air (Table 7). This fact was also observed by Takino and Maier (1997) for Uma River, also located in Ibiúna-SP and immediately aside of the PA watershed. The mean difference among air and water temperatures was 2.5 °C. Data of water temperature were directly correlated with air temperature ($r = 0.80$, $P < 0.05$, Table 8). Season was the main criteria where data regarding air and water temperature presented significant differences. Neither by watershed, or by the landscape position, did variables show significant differences (Tables 9–11).

In few occasions, the values of some data were worse than the limits stipulated by the Environmental Brazilian regulatory agencies (CONAMA (Brazilian National Bureau for Environment), 2005; CETESB (São Paulo State Environmental Company), 2009). The land

Table 5

Mean and coefficient of variation of the soil attributes according to land cover category of SO watershed. For each soil attribute, different letters mean difference statistically significant according to Kruskal Wallis test ($P < 0.05$).

Land cover and number of samples	Agriculture ($N = 20$)		Natural remnant vegetation ($N = 10$)	
Soil attributes	Mean	CV (%)	Mean	CV (%)
Bulk Density (g/cm^3)	0.95a	15.6	0.62b	26.3
δ^{15}N (‰)	8.75a	20.1	6.21b	19.5
N (g/kg)	1.59a	41.5	3.71b	39.7
δ^{13}C (‰)	−21.75a	14.3	−26.22b	7.3
C (g/kg)	22.70a	42.8	52.75b	43.1
C stock (Mg/ha)	28.15a	42.5	59.54b	24.8
C:N ratio	14.39a	11.4	14.31a	10.8

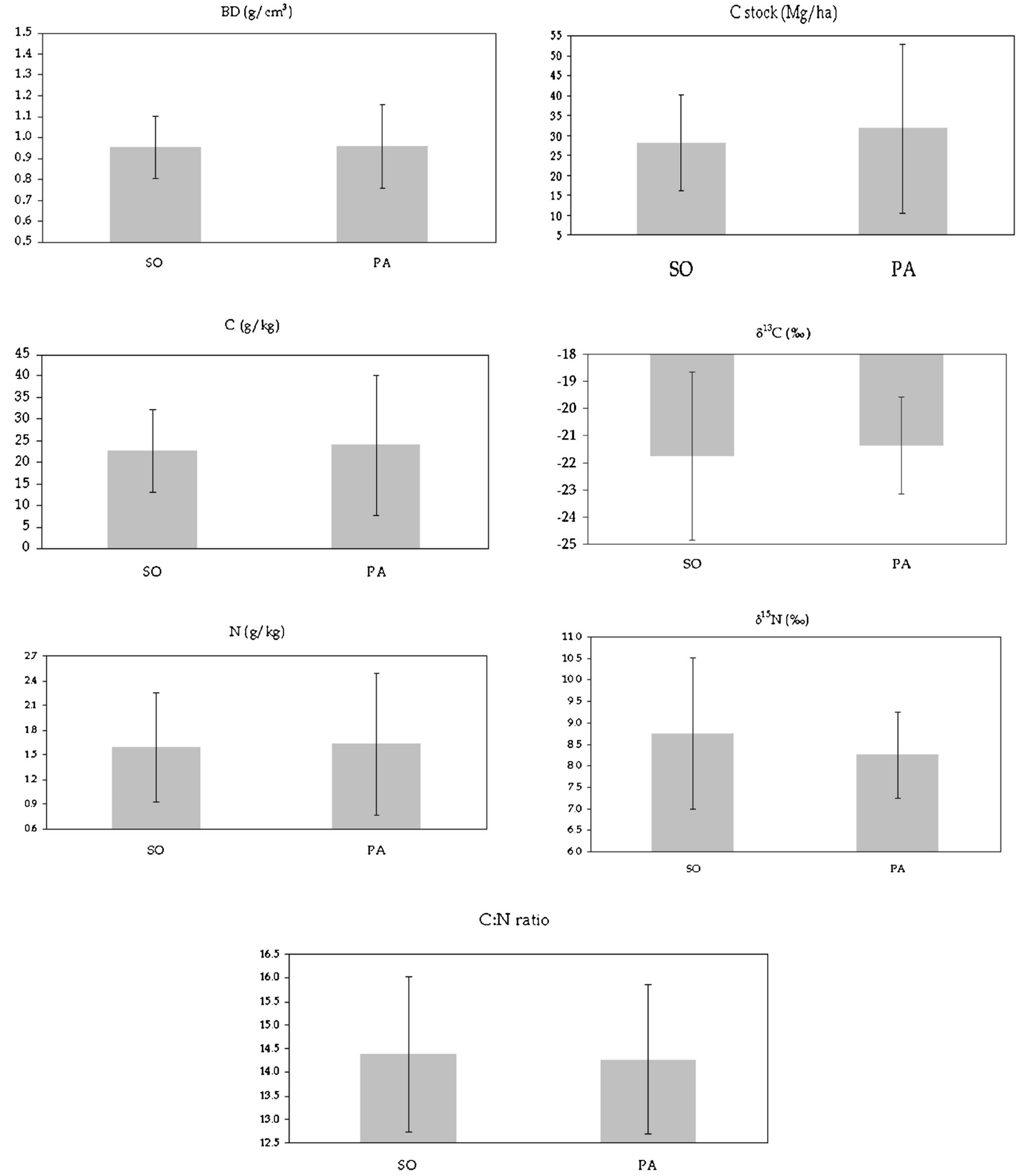

Fig. 2. Mean values and standard deviation of the soils samples according to farming system in the SO and PA watersheds. In all attributes non-significant statistical difference were reported among the farm systems ($P < 0.05$).

use (predominantly rural) within the watersheds and the expressive portion of the land still forest-covered as well (approximately 38.7% in each watershed) are the main cause for these results.

All values of pH were in accordance with legislation and presented no significant differences in none of the criterion of separation. Dissolved oxygen was the variable with greatest occurrence of values greater than the limit established in the legislation, although the difference among the values and the limiting value were not greater than 16%. This variable was statistically similar among the groups of the three considered criterion.

Table 6
Carbon Management Index for the soils from the two farms systems.

	Carbon Pool Index	Lability	Lability index	Carbon management index	
SO	Reference lability value of Remnant Natural Vegetation of SO = 2.02				
	Agriculture	0.47	1.96	0.97	42
PA	Reference lability value of Remnant Natural Vegetation of PA = 1.62				
	Agriculture	0.52	1.56	0.93	50

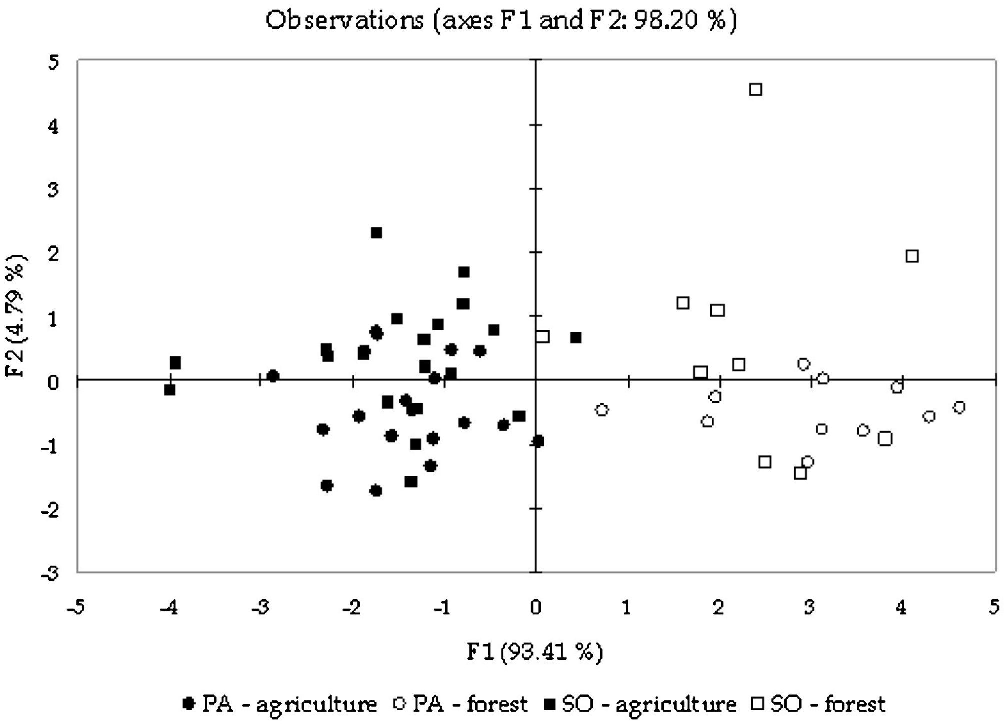

Fig. 3. Scatter diagram of samples according to the sites of the four considered land cover categories and farm systems.

Table 7
Database regarding water attributes for the study areas.

Attribute	Season	PA Upper	PA Middle	PA Low	SO Upper	SO Middle	SO Low	LV
Air temperature (°C)	Dry	18.3	19.2	20.0	19.2	18.1	18.3	–
	Rain	22.7	26.9	25.3	26.5	23.5	31.0	
Water Temperature (°C)	Dry	18.2	17.5	18.0	17.3	17.5	17.5	–
	Rain	22.1	22.0	23.0	21.1	21.6	23.1	
pH	Dry	6.5	7.0	7.3	6.7	6.9	7.2	6.0–9.0
	Rain	6.8	7.2	7.3	6.5	6.7	7.5	
Dissolved oxygen (mg/L)	Dry	5.6	7.0	4.2	6.5	4.9	4.9	≥5.0
	Rain	6.0	4.5	4.4	6.0	4.5	5.6	
Salinity (‰)	Dry	0.19	0.19	0.24	0.19	0.20	0.23	≤0.50
	Rain	0.20	0.19	0.27	0.20	0.21	0.25	
Total of Dissolved Solids (mg/L)	Dry	216	221	315	229	241	300	≤500
	Rain	213	193	327	217	242	292	
Total Solids (mg/L)	Dry	550	590	760	620	680	600	Virtually absent
	Rain	720	790	950	1030	820	1080	
Electric Conductivity (μS/cm)	Dry	30.4	31.1	44.4	32.3	34.0	42.3	≤100.0*
	Rain	30.0	27.3	45.8	30.3	34.0	39.8	
Turbidity (NTU)	Dry	10	17	15	30	81	21	≤100
	Rain	8	9	6	39	86	10	
Total Chloride (mg/L)	Dry	20.0	30.0	20.0	10.0	20.0	10.0	≤250.0
	Rain	40.0	30.0	30.0	40.0	20.0	30.0	
Nitrate (mg/L)	Dry	0.5	0.4	0.5	0.6	1.0	0.6	≤10.0
	Rain	0.5	0.3	0.2	0.1	0.5	0.3	
Total phosphorus (mg/L)	Dry	0.02	0.02	0.03	0.02	0.02	0.02	≤0.05
	Rain	0.02	0.07	0.02	0.02	0.02	0.02	
Potassium (mg/L)	Dry	1.00	0.93	1.15	0.96	1.03	1.27	≤10.0*
	Rain	1.07	0.86	1.32	1.17	1.46	1.27	

LV—limiting values recommended according to Brazilian Federal Law (CONAMA (Brazilian National Bureau for Environment), 2005).
*—limiting values suggested by São Paulo State Company for Environment as indicator of water of good quality (CETESB (São Paulo State Environmental Company), 2009).

Table 8
Correlation matrix for water attributes (values in bold mean significant correlation at $P < 0.05$).

Attributes	Water temp	pH	Dissolved O_2	Salinity	TDS	Total solids	EC	Total Cl	Nitrate	Turbidity	Total P	Potassium
Air temp	**0.80**	0.31	−0.17	0.32	−0.05	**0.86**	−0.13	**0.64**	**−0.82**	−0.34	0.29	0.27
Water temp		0.33	−0.31	0.47	−0.01	**0.73**	−0.03	**0.67**	**−0.68**	**−0.59**	0.09	0.43
pH			−0.48	**0.63**	0.58	0.33	**0.59**	0.04	−0.19	−0.43	0.38	0.21
Dissolved O_2				**−0.59**	−0.52	−0.35	−0.53	0.20	0.04	0.11	−0.54	−0.43
Salinity					**0.83**	**0.60**	**0.80**	0.04	−0.19	−0.11	−0.07	**0.86**
TDS						0.25	**0.99**	−0.39	0.09	0.17	−0.12	**0.69**
Total Solids							0.17	0.51	**−0.64**	−0.07	0.13	0.56
EC								−0.45	0.16	0.13	−0.12	**0.64**
Total Cl									**−0.77**	−0.47	0.02	−0.01
Nitrate										0.39	−0.15	−0.15
Turbidity											−0.28	0.16
Total P												−0.36

Most data of salinity were almost half of the maximum limiting value and the values were practically identical among the groups, independently of the criteria of differentiation. For the total dissolved solids (TDS) the data were less than the limiting value in all occasions. We observed significant difference when the data are separated according to position in the landscape, whose difference of 41% (significant $P < 0.05$) occurs among the data of sampling points located in upper and lower regions of watersheds. Salinity and TDS presented a significant correlation ($r = 0.83$, $P < 0.05$).

For the variable total solids (TS), Brazilian legislation does not specify a numeric-limiting value and merely presents the phrase “virtually absent”. For water from rivers, streams, creeks, lagoons and many others superficial water bodies, natural or artificial, degraded or not, some amount of suspended material always exits, living or not, organic or mineral, particulate or dissolved, and the concentration of such material, as a whole or fractioned, is highly variable in time and spatially and is context dependent. For this attribute, a significant difference was noted when the data are separated considering the seasonality. This is expected because during the rainy season a greater volume of material is transported by water. The other two criterion of separation did not present significant differences. This variable was also significantly correlated with salinity ($r = 0.60$, $P < 0.05$).

Values of electric conductivity (EC) were expressively less than the limiting value. For this variable we found a significant difference when data were recombined considering the criteria landscape position of the sampling points (upper and low regions presented significant differences for EC). EC data was highly correlated with TDS values and potassium was the only ion that had a significant correlation.

Turbidity was the only variable where significant difference among the watersheds showed up. Data regarding this variable had a significant correlation with water temperature and in 56% of the total the data the values are 50% less than the limiting value. Values regarding total chloride were all less when compared with the limits established by Brazilian legislation. Data presented significant differences when considered the criteria “season”, once that the mean value of the campaign of collection was carried out in the rainy season was almost twice greater than the mean value of the samples from dry season. Values of nitrate were expressively less than limiting-established value. As an example for chloride, for criteria “seasons”, a significant alteration of the nitrate concentration was found. However, the mean value of the samples collected during the dry station was twice greater than the mean values of that ones taken in the rainy station.

For phosphorus, only in one occurrence was the limiting value exceeded (collected in PA–middle—rainy season, value: 0.07 mg/l) and the variation in the SO values was verified only in the thousandth’s decimal places. The values of Trophic State Index (STI) ranged from 235 to 242 and all sampling points were classified as eutrophic, according to classification of Lamparelli (2004). None criteria of arrangement of data had significant differences. Concerning potassium, values were all expressively low, much lower than the limiting value and without significant differentiation among the groups established by separation criterion and this variable had a significant correlation with TDS, salinity and EC.

Regarding the PCA carried out using water attributes, the correlations between attributes and factors are shown at Fig. 4. From the four quadrants of the graphic, the left side is occupied only by three attributes (nitrate, turbidity and dissolved oxygen). The coordinates of the others attributes were located on the right side, half

Table 9
Means and coefficient of variation for the water attributes according to criteria of separation “watersheds”. For each attribute, data not followed by letter means that the difference is not significant, and different letters appear there is significant difference according to Kruskal–Wallis test ($P < 0.05$).

Attribute	PA		SO	
	Mean	CV (%)	Mean	CV (%)
Air temperature (°C)	22.1	15.8	22.8	23.0
Water Temperature (°C)	20.1	12.3	19.7	13.0
pH	7.0	4.5	6.9	5.4
Dissolved Oxygen (mg/L)	5.3	21.0	5.4	14.2
Salinity (‰)	0.21	15.9	0.21	10.6
Total of Dissolved Solids (mg/L)	248	23.4	254	13.5
Total Solids (mg/L)	727	19.9	805	26.0
Electric Conductivity (μS/cm)	34.8	23.2	35.5	13.0
Turbidity (NTU)	11a	39.3	45b	71.3
Total Chloride (mg/L)	28.3	26.6	21.7	54.0
Nitrate (mg/L)	0.4	31.6	0.5	59.2
Total phosphorus (mg/L)	0.03	66.7	0.02	0.0
Potassium (mg/L)	1.06	15.6	1.19	15.2

Table 10
Means and coefficient of variation for the water attributes according to criteria of separation “season stations”. Attributes with data not followed by letter the difference is not significant and different letters appear there is significant difference according to Kruskal–Wallis test ($P < 0.05$).

Attribute	Dry		Rain	
	Mean	CV (%)	Mean	CV (%)
Air temperature (°C)	18.9a	3.9	26.0b	11.4
Water temperature (°C)	17.7a	2.0	22.2b	3.5
pH	6.9	4.3	7.0	5.6
Dissolved oxygen (mg/L)	5.5	19.3	5.2	15.1
Salinity (‰)	0.21	10.9	0.22	14.7
Total of dissolved solids (mg/L)	254	16.9	247	20.9
Total solids (mg/L)	633a	11.9	898b	16.0
Electric conductivity (μS/cm)	35.8	16.9	34.5	20.3
Turbidity (NTU)	29	90.8	26	120.5
Total chloride (mg/L)	18.3a	41.1	31.7b	23.8
Nitrate (mg/L)	0.6a	35.0	0.3b	50.6
Total phosphorus (mg/L)	0.02	18.8	0.03	72.0
Potassium (mg/L)	1.06	12.2	1.19	17.6

Table 11
Means and coefficient of variation for the water attributes according to criteria of separation "localization in the landscape". Attributes with data not followed by letter the difference is not significant and different letters appear there is significant difference according to Kruskal–Wallis test ($P < 0.05$).

Attribute	Upper		Middle		Low	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Air temperature (°C)	21.7	17.2	21.9	18.5	23.7	24.3
Water temperature (°C)	19.7	11.6	19.7	12.7	20.4	15.0
pH	6.6	2.3	7.0	3.0	7.3	1.7
Dissolved oxygen (mg/L)	6.0	6.1	5.2	22.9	4.8	13.1
Salinity (‰)	0.20	3.0	0.20	4.85	0.25	6.9
Total of dissolved solids (mg/L)	219a	3.2	224a,b	10.2	309b	5.1
Total solids (mg/L)	730	29.0	720	14.7	848	24.9
Electric conductivity (μS/cm)	30.8a	3.4	31.6a,b	10.1	43.1b	6.1
Turbidity (NTU)	21	74.4	48	84.7	14	43.0
Total chloride (mg/L)	27.5	54.5	25.0	23.1	22.5	42.6
Nitrate (mg/L)	0.4	52.2	0.6	56.5	0.4	45.6
Total phosphorus (mg/L)	0.02	0.0	0.03	76.9	0.02	22.2
Potassium (mg/L)	1.05	8.8	1.07	25.2	1.25	5.8

of them in the upper-right quadrant, and the other in the bottom-right quadrant. Factors 1, 2, and 3 explained together 81.91% of the overall variance of the data. Axes F1 and F2 explain together 68.22%. Salinity, TS, water and air temperatures were the major contributors in the F1 (50.1% of the total of this factor). EC, total chloride, TDS and nitrate represent predominated in the F2 (61.6% of the total), and total phosphorus, pH, potassium, dissolved oxygen and turbidity represent predominated the F3 (92.1% of the total).

5. Discussion

5.1. Soil attributes

BD data show that soils from Ibiúna are highly prone to compaction for land cover shifting from forest to cultivation. Such information was already observed by Manfré et al. (2011a) also for pastured areas in the same studied watersheds. Textural attributes have a discrete participation in the BD, but BD did not have a significant correlation with textural attributes (sand, silt or clay). On the other hand, SOM exerts a significant influence over the changes in BD, supported by significant inverse correlation value with C concentration ($r = -0.69$, $P < 0.0001$). After removing the forest cover and using the area for tillage, soils can become significantly compacted and unbalanced in terms of the occurrence of macro and mesopores. Only micropores exist then, with hydraulic conductivity and water storage diminished and other problems, such as soil erosion, might arise.

Crop rotation is a delicate issue in the farms in Ibiuna, because when the farmers are queried (both organic and conventional) about the adoption or not of the crop systems, the response is affirmative (Blanc, 2009). However, few farmers have strictly applied crop rotation, because the market demands specific high-value

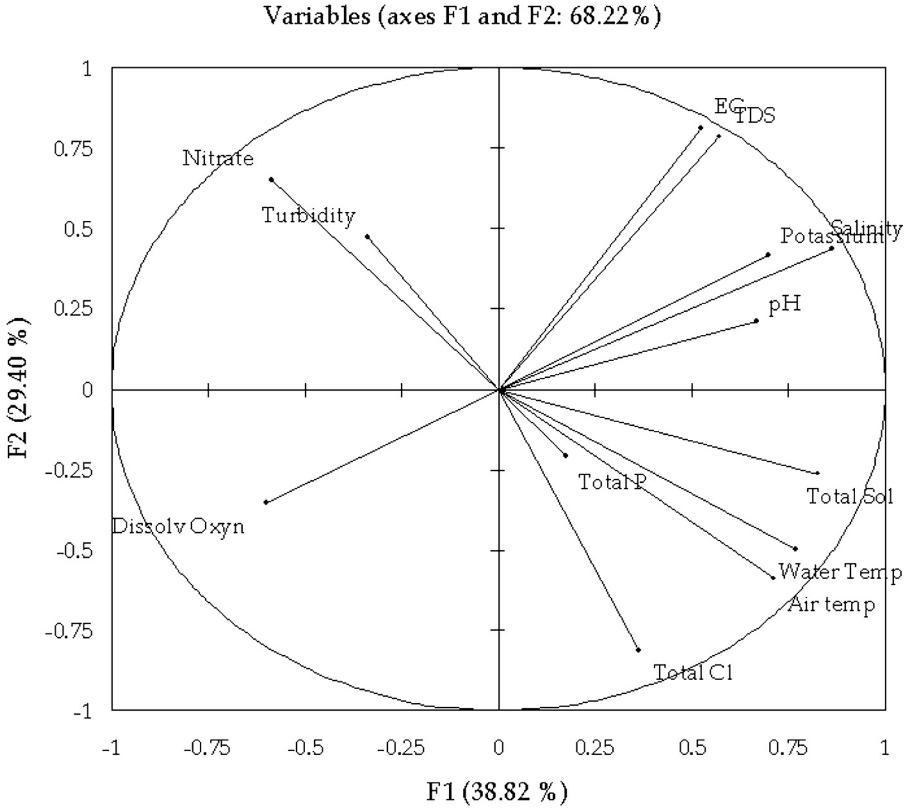

Fig. 4. Scatter diagram of the PCA showing the location of the water attributes.

crops such as various varieties of lettuce (Kerber and Abreu, 2010; Oelofse et al., 2011), so at most they change the variety of lettuce for instance and call it as crop rotation. In the studied region, the form as the crop rotation have been practiced, whatever is the farming system, is a component of low efficacy of soil management and an important factor that explains the high similarity among the watersheds and expressive differences among soils from cultivated and forest-covered sites (Valarini et al., 2011). Such authors detected loss in the soil aggregate stability and attributed this to reduction of soil C, as well as loss of C from the microbial biomass.

It is well known that some mechanisms of SOM protection exists, including physical, chemical and biochemical, and that soil tillage accelerates the process of SOM oxidation. Here we infer that the light fraction and particle organic matter (POM), especially coarse POM (>250 μm), are the main fractions of C that are being lost, because they are relatively easily decomposable and they are greatly depleted upon cultivation, indicating their relatively unprotected (physical and biochemical) status (Six et al., 2002). This occurs mainly due the rupture of the macro aggregates and exposition of portions of SOM previously bound in the inner parts of the aggregates and the C is usually lost to the atmosphere. This fact is here proven by significant reduction of C concentration of soils from cultivated sites in both watersheds and this is a special point that organic farmers should avoid in order to keep the soils healthier (Naturland, 2014). Even considering the addition of organic fertilizers in organic farms, especially manure, whose amount was not revealed by the farmers, the values of C concentration are not significantly different among the farming systems. The reduction of the C concentration directly reflects the amount of C stored in the soils. The problem of a decrease in C store was also reported in organic farm systems from European regions (Marinari et al., 2006). In general terms, although the data for BD influences significantly the C stock ($r = -0.67$, $P < 0.05$) the C concentration influenced much more the final values of C stock ($r = 0.98$, $P < 0.05$).

The C concentration is an effective indicator of soil quality (Karlen et al., 2003) and we affirm that the forested soils from Ibiúna have a high soil quality, because the C concentration is comparable with forest-covered of other biomes occurring within Brazilian territory, for example: Amazon: 31.7–44.5 g/kg (Hughes et al., 2002), and the Savannah region 19.9–38.9 g/kg (Costa Junior et al., 2011). Hence, we affirm again that the tillage of soil has depleting its quality and has deteriorated part of the ecosystems services provided by the soils of this region.

Values of the abundance of ^{13}C in forest-covered sites agree with those presented in the literature. However, in cultivated sites there is the influence of material more enriched in ^{13}C in the SOM, both in organic and conventional watersheds. Taking into account that in both forest and agricultural sites the main component that drives the ^{13}C abundance in the SOM is the C introduced via plant-derived organic material (Kayler et al., 2011), and also considering that most of cultivars in both watersheds includes plants with photosynthetic pathway C_3 (COAGRI (Cooperative of Organic Farmers and Solidarity Ibiúna), 2013), it is difficult identify other sources of depleted ^{13}C.

Values of δ^{15}N of forest soils are lesser than agricultural soils and are also reported in other studies (Yoneyama, 1996). Our data both of N concentration and δ^{15}N data show that (a) in the cultivated areas the N cycle in the soil is expressively altered and (b) the farming systems are not approaching the N cycle of the natural N cycle occurring in forest-covered sites. Many parts of N cycling in the soil are dependent of multiple microbiological activities occurring in the soil (Templer et al., 2012). Assuming that the input of N via atmospheric precipitation is spatially uniform over the two watersheds, and also considering the use of chemical fertilizer amendments in conventional farms and organic fertilizer amendments in the study areas, we verify that the soils from cultivated areas become less efficient in conserving and recycling N than forested soils, evidenced by more enriched of ^{15}N values found in soils from cultivated sites.

One component that drives the efficiency in conserving the N is the alteration of the soil microbiological community (Robinson, 2001). In other study carried out in the same region, Valarini et al. (2011) reported that microbe biomass was significantly different among cultivated and pristine areas and not significantly different among the farming systems. The authors attributed this fact to the nonexistence of a fallow phase. The fallow phase is the period between two crops, where the aim is to store and conserve soil moisture and N for the next crop (Reitano and Watts, 2006). Hence we stress that practicing the crop rotation using plant species that allocate more C below-ground, avoiding or reducing use of uncovered fallow (Gattinger et al., 2012) are some agronomic techniques recommended to improve the present scenario. Hence, during the fallow phase the ground should be covered with mulch or similar material, instead of be kept uncovered and unprotected.

Additionally, enrichment of δ^{15}N might be caused by an intensification of the loss of ^{15}N-depleted compounds in cultivated soils, leaving behind enriched-^{15}N compounds. Volatilization is one of the major steps responsible for N fractionation and the absence of forest cover might increase this process (Yoneyama, 1996). Moreover, although it is a minor step, (Yoneyama, 1996) ^{15}N-soil enrichment by hydrological processes may occur, especially leaching, because ^{15}N-depleted nitrate is lost with leached aqueous solution (Boeckx et al., 2005). For our study area, this modality of N fractionation is greater in soils from forest sites, because they are more porous and in cultivated water infiltration in the soil profile is diminished, indicated by the increasing of BD. Nevertheless, cultivated sites are losing more N than forested sites, independently of the farming system. Considering that the use of manure is highly encouraged in organic farm systems to feed the soil and the organisms living within it (Naturland, 2014) and the application of manure in organic farming trends to elevate the value of δ^{15}N in the soil (Choi et al., 2003), the non-significant differences observed in this study among the two farming systems suggests that the organic farmers have either used insufficient quantities of manure or not using this kind of amendment.

The C:N ratio was the unique variable with non significant difference among soils from cultivated and forested areas in SO watershed, although it was significant in PA. Considering all soil samples, independent of type of land cover or farming system, the C:N ratio was significantly and negatively correlated with δ^{15}N values ($r = -0.35$, $P < 0.05$). Few studies have noted the relationship of C:N ratio and δ^{15}N. Stevenson et al. (2010) studied the relation of type and intensity of land use and the level of correlation among C:N ratio and δ^{15}N values in subtropical soils from New Zealand. As we found in this study, they verified a significant, negative correlation of C:N ratio and δ^{15}N values ($r = -0.73$). Similarly, they also verified that cropped sites had greater values of δ^{15}N. However, comparing the C:N ratio they found greater values for forest-covered soils (mean value 16.8) than tilled soils (mean value 11.8).

The PA watershed had values of C management index (CMI) slightly greater than SO. Is appears that there is no pre-established, ideal value of CMI. Such an index provides a sensitive measure of the rate of alteration in soil C dynamics of systems relative to a more stable reference soil. This index shows if the system is in decline (for values lower than 100) or being rehabilitated, in the case of temporal increasing in the value (Blair et al., 1995). Considering that for organic farming system it is expected that better values for CMI occur than conventional farming systems (Leite et al., 2003), this index supports the finding that the soil management in the organic farms should be evaluated more rigorously in order to effectively improve the soil quality in the local rural properties. To improve the scenario here reported, four major activities should be effectively considered by the farmers in order to optimize the management of the edaphic microbiological community and the soil C management: management of soil pH, incorporation of new fibrous plant-derived organic material, maintenance of fertilization and including a crop rotation system (Primavesi, 1987).

The LDA graphically confirmed most of the trends already reported. The percentages of mismatch observed in the results provided by the classifier confirm the high difference among the land cover categories and the high similarity of the soil data from cultivated areas of the two farming systems.

5.2. Water attributes

Biogeochemical processes in rivers are governed by the interplay of chemical, geomorphic, hydroclimatological and biological processes. The data regarding dissolved oxygen (DO) allows for the aerobic process of respiration in the superficial waters along the entire study areas. Typical problems regarding absence of dissolved oxygen in water, like dead fish arising (which usually do not endure concentrations beneath of 4.0 mg/L (Welch and Jacoby, 2004)) and smell, were not reported neither during the field incursions nor by local dwellers. We verified onsite that the flow of river water is predominantly turbulent through practically the entire channel. Hence, the level of DO is probably uniform along the water column. No significant differences were verified suggesting that input of allochthonous organic material from terrestrial parts in the catchment areas has not altered the oxygenation pattern of such streams.

All sampling points were classified as eutrophic. Eutrophicated water bodies can naturally occur in nutrient-rich regions with a high net primary productivity. However, anthropogenic activities usually are major driving forces in accelerate the eutrophication process due the input of phosphorus-concentrated products into water bodies. Major anthropogenic activities responsible by the enrichment of phosphorus in water bodies are industrial and domestic sewage, use of enriched-phosphorus fertilizers, and dust from various sources transported by the atmosphere. Onsite we observed at each sampling point that the surrounding riparian vegetation occurred in variable proportions. In the sampling point “PA-middle” there an area of horticulture near the channel and at the sampling point “PA-low” there is a small agglomeration of houses. Near all the sampling points there were roads. In the sampling point “SO-low” there was also horticulture near the sampling point; although this fact seems not having a significant influence over the level of phosphorus of the water.

Values of TDS represented approximately 34% of the TS, although such attributes were poorly correlated ($r = 0.25$, not significant at $P = 0.05$). Usually, high values of TS are related to rural land use (Welch and Jacoby, 2004) and our data match this statement. High levels of suspended solids can act as carriers of toxic materials, which readily cling to suspended particles. This is particularly a concern for locals where toxic products are being used on irrigated crops. Where suspended solids are abundant, concentrations of pesticides and similar might occur well beyond those of the original application as the irrigation water travels down irrigation ditches (APHA (American Public Health Association), 1999). This is particularly alarming information for our study areas because of resistant weeds that demand expressive amounts of pesticides, in areas of potato, tomato and lettuce. The use or not of pesticides is a factor that effectively differentiate among conventional and organic farm systems (Bellows, 2002; Naturland, 2014) and the concentration of some products in the water both in PA and SO watersheds should be investigated in future projects.

Nitrogen and phosphorus are the primary macronutrients responsible for the eutrophication process in streams and rivers. While phosphorus is the key nutrient limiting productivity and causing excess algal biomass in most lakes and reservoirs worldwide, N may have more importance as limiting element of biomass in streams. Either way, the very low values found in this study indicate at least during the period of study, only a modest amount of nitrate pollution in the streams occurred. Natural processes and anthropogenic activities determine concentration of nitrate in water. Fertilizers containing nitrate are an important source of nitrate that can get into water directly as the result of runoff. Moreover, a minor amount of nitrate enters water by precipitation, which carries nitrogen-containing compounds derived from automobiles and other sources (Welch and Jacoby, 2004).

Some researches point out that major concentrations of nitrate are found in the rainy season. In predominantly forested watersheds, nitrate might be predominantly derived from nitrification processes in soils, resulting in relatively low concentrations. In watersheds with significant agricultural and urban land use, values of nitrate are expressively altered, normally caused by admixture of fertilizer, sewage- and manure-derived nitrate, according to the context (Mayer et al., 2002). For the case of our study area, the areas with forest cover are different in the N export rates from the soil to the stream network.

Salinity and electric conductivity (EC) were significantly correlated and both had a significant positively correlation with pH values. Due to the fact of the water is not excessively acidic ($\text{pH} > 5.0$) this suggests discrete participation of ion H^+ in EC and salinity (Wetzel, 2001). Both EC and salinity are highly influenced by the presence of some dissolved anions and cations, present in inorganic form and some of them are macronutrients.

Organic products like oil, alcohol, and sugar do not conduct electrical current very well and, therefore, have a low conductivity when in water. In specific terms, this might be relevant information for our data, because in all sampling points there was a road near of the river channels and the road might be a source of organic products, although not visually observed in the water. Comparatively, our data agree with the EC data surveyed by Takino and Maier (1997) in the Una River, another rural watershed located in Ibiúna, whose modal values changed from 34 to 40 μS/cm. According to authors, such low EC values found in region might be attributed principally to granitic-derived geological basement rock that usually holds low amounts of ions.

Turbidity was the unique water attribute where the watersheds presented significant differences. Taking into account specifically the sampling point SO-middle, we verified that this point had the greatest values for both sampling campaigns. However, we observed onsite and through digital aerial photography that this sampling point was surrounded by riparian vegetation of good quality. Perhaps the source of the materials that’s getting into the watercourses and causing the turbidity was located upriver. However, the high value of turbidity was not “transferred” to the lower sampling point SO-low. The data showed a better condition in the two seasons. The occurrence of tributaries with crystalline water entering improves the water turbidity.

Water turbidity can have a significant correlation with TS and TDS, creating a potential to indirectly estimate the concentration of TS or TDS (Udeigwe et al., 2010). However, in our study turbidity had a poor correlation with both TS and TDS, a fact that was also reported by Riley (1998) and Daphne et al. (2011). According to these authors, more than a simple refraction of the light, the kind of material of particulate nature (biological organisms, organic or mineral particles of different shape and color), as well as the kind of dissolved material is equally important and drives the potential of refraction of the light in relation to the quantity of material, dissolved or particle in the mass of water.

Among the nutrients, only potassium had a significant correlation with EC, salinity and TDS, and showed a discrete, not significant increase from the upper to low parts over both watersheds. In fact,

Table 12
Variation of values of electric conductivity in Ibiúna.

Compartments	Rainwater	Soil		River water	
Mean and extreme values (μS/cm)	17.5 (15.0–20.0)	SO–cult	147.3 (21.8–412.0)	SO	35.5 (30.0–42.3)
		SO–for	146.3 (67.5–199.8)		
		PA–cult	194.6 (40.5–485.0)	PA	34.8 (27.3–45.8)
		PA–for	158.7 (11.6–278.0)		
Sources	Conceição et al. (2011)	Manfré et al. (2011a)		This study	

this is one of the major cations that drive the values of EC and salinity, although seldom it is an actual limiting factor for ecosystem metabolism. Although the concentration of potassium in stream water normally is directly related to use of mineral fertilizers in surrounding areas (Biggs et al., 2002). For our study areas, the mean value for potassium was greater, but non significant, for the SO watershed, where organic farm system is practiced.

5.3. An integrative glance

One of the best options to make an integrated description of the relations between the components (atmosphere, soil and water) is by analyzing the electrical conductivity of water, because the measurements of this attribute are simple, inexpensive and can provide valuable data for watershed research and management. Taking into account the data provided in Table 12, we see that the EC of river water are doubled in relation to rainfall water, while for urban watersheds in USA this value increased 30 times (Pellerin et al., 2008). According to data of soil EC provided by Manfré et al. (2011a) almost all sampling points had a soil EC value greater than the upper limiting value of EC of rainwater (excepting one), meaning that the local soils area a major source of ions for the stream rather than rain.

For stream water the ion chloride is the predominant counter ion in this study and might be more directly related to punctual sewage inputs and human density than agricultural sources. This inference is based in the resulted provided by Phillips (1994) who investigated the chloride concentrations in water samples collected from 42 watersheds in USA, and the results ranged from less than 2 mg/L in watersheds with population density less than 0.2 inhabitants/km^2 to more than 100 mg/L in watersheds with a population exceeding 200 inhabitants/km^2. Regarding rainwater, for Ibiúna, calcium is predominant and probably the controlling factor of the regional rain acidity (Conceição et al., 2011).

In terms of transfer of pollutants from the soil to water bodies, in cultivated areas the chance of occurrence of runoff is greater because the soils are more compacted. Increasing runoff, and it is expected to increase sediment and pollutants delivery ratio. Thinking ahead, according to onsite checks, deforestation for agricultural uses still occurs. The installation of many crops in large, sloping areas with nearby water courses was also noticed. In addition, the machinery used for cultivating soil, increases the soil exposure to erosive process (Manfré et al., 2011a).

Assis and Romeiro (2007) considered several organic farms located in Ibiúna, as part of a set of organic farms located in São Paulo in a study where they verified that, according to most of the landowners who practice the organic farming system, there is a time lapse after the conversion from conventional to organic in order to recondition the soil. The local farmers also state that normally the "aspirant" organic farmer needs time to learn about the soil management under the organic system.

Taking into account that short term organic farmers in Ibiúna have actual have been concerned with environmental problems, hence it is possible to comprehend the main reason that leads the landowners to change the farming system is the improvement of economics rather than a preoccupation with health or environmental improvements and our data confirms this tendency. Farmers should recognize themselves as part of the problem and the solution of the regional environmental problems, and should to be encouraged to intensify agroecological approaches that seek to manage landscapes for both agricultural production and ecosystem services while obtaining greater financial rewards for improving agricultural productivity under sustainable ways (Rosegrant and Cline, 2003; Kay et al., 2012).

6. Conclusions and final remarks

Our data show that the soils from Ibiúna have a modest land use capability because they are highly prone to compaction and degradation. Soil and water have characteristics not significantly different in both organic and conventional farms regions, indicating that in Ibiúna, after approximately fifteen years after conversion, organic farming system did not improve the qualities neither of soil or water of the studied watersheds, meaning be of low ecological efficiency in terms of restore the soil quality.

Most of the water quality attributes and within the limits established by legislation, but the streams of both watersheds were considered eutrophic. The need for this type of research is explained by the fact that the studied region is of high value for providing agricultural products for a large number of people located in the most populous Brazilian region, and a knowledge regarding the impacts on soil and water that the farmers have caused is still poor.

Whilst organic farmers abide to organic rules, the gap between what the standards require and the organic principles is the main fact that explains the similarity in the ecological indicators (soil and water) here surveyed. The interest for organic products is increasing and several Brazilian banks have opened special financial credits for farmers interested in organic agriculture. Hence, to be ecologically more efficient, organic farmers should consider more rigorously the principles of organic agriculture, mainly modifying some agronomic practices—for example, avoiding use of bare soil during the fallow phase on their farms, they should avoid further deforestation in order to maintain or improve the water quality of the local streams and consider more seriously some principles of organic agriculture, for example the employment crop rotation systems.

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