This article is presented in Portuguese and English with "resumen" in Spanish.
Brazilian Journal of Applied Technology for Agricultural Science, Guarapuava-PR, v.4, n.2, p.07 –29, 2011.

Scientific paper

Analysis of soil aggregate stability on the Ribeirão São Domingos watershed, Santa Cruz do Rio Pardo, São Paulo state, under different land uses and occupations

Julio Cesar Demarchi [1]
Maria Cristina Perusi [2]
Edson Luís Piroli [3]

Abstract

The soil use and its agricultural and urban management, as well as causing changes on its chemical and physical properties, affect its aggregate stability and consequently its resistance to the erosion. This paper aimed to evaluate the chemical and physical properties as well as the soil aggregate stability on the Ribeirão São Domingos Microbasin, Santa Cruz do Rio Pardo city, in five land use systems: Sugarcane cultivation (SU), Pasture (PA), Urban land (UL), Native Forest (NF) and Soybean cultivation in rotation with winter crops (SCWC). The aggregation indexes analyzed showed, in descending order of structural quality, the following land use systems: PA, NF, SCWC, SU and UL. The main factors that have influenced the soil aggregation are its use and management, which are directly related to the vegetation cover and the organic matter supply and maintenance. The land use system SCWC presented the most appropriate chemical features because of the crop system and fertilization adopted, and the NF one presented bulk density and porosity similar to a natural system.

Palavras-chave: land use; soil management; aggregate stability; chemical properties; physical properties.

Introduction

In its natural condition, soils present different degrees of susceptibility to erosion, which come from the chemical and physical properties as texture, porosity, soil density, structure, among others. Besides that, the morphology of the hillside, declivity, ramp length and rainfall erosivity are determining factors in this process. The agricultural and urban uses commonly result in changes in the aggregation and stability of the soil aggregates. This property is considered by some authors as important indicator of the soil quality, considering that, the higher their aggregation and stability, the higher the resistance to water erosion (BARBOSA et al., 1998; CHAVES; CALEGARI, 2001).

According to AZEVEDO and DALMOLIN (2004), the formation of the aggregates of the soil depend on the factors which promote the approximation of the primary particles, and on the factors which maintain the particles united against the forces that tend to separate them. The factors which promote the approximation of the particles are: the flocculation of the clays, the physical-chemical process dependent on the pH and on the cations present in the soil solution and adsorbed; physical processes as dehydration

Received in: 16/04/2011 Accepted for publication: 19/08/2011

1- Student of the Master's degree in the Program of Post-Graduation in Agronomy (Energy in Agriculture), Faculty of Agronomic Sciences from Unesp – Câmpus of Botucatu-SP. Botucatu – SP. E-mail: julio.demarchi@gmail.com.

2 - Professor Assistente* Doctor in the course of Geography from Unesp – Câmpus Experimental de Ourinhos. E-mail: cristina@ourinhos.unesp.br.

3 - Professor Assistente* Doctor in the course of Geography from Unesp – Câmpus Experimental de Ourinhos. E-mail: elp@ourinhos.unesp.br.

* Brazilian Academic Degree

and the pressure exercised by roots; and the soil organisms. According to the referred authors, the main agents which give stability to the aggregates are: clay minerals, iron and aluminum oxides and the organic matter, besides microorganisms, which produce substances that act as stabilizing agents or work as net involving the aggregates of the soil, as the fungi hyphae associates with small roots.

PERUSI (2005) affirms that the different systems of soil use and management influenced the formation and stability of their aggregates. The intense revolving of the superficial layers, the higher incorporation of the organic matter, the constant movement of the agricultural implements and the animal trampling contribute to cause changes in the soil structure, which promote the alteration of other properties, as density and porosity, resulting in the compromising of the productive capacity of this natural resource. In these conditions, the structural quality of the soil becomes a tool of evaluation of the systems of use and management.

According to KEMPER (1965) and KEMPER and CHEPIL (1965) cited by CASTRO FILHO et al. (1998), it can be used as parameter of evaluation of the size of the aggregates and of the stage of soil aggregation the Weighted Mean Diameter (WMD), the Geographic Mean Diameter (GMD) and the Aggregate Stability Index (ASI), which present, each one, a different principle: WMD is higher when the percentage of aggregates retained in the sieves with larger mesh is high; GMD represent an estimate of the size of the class of aggregated with larger occurrence; and ASI represent a measure of total aggregation of the soil, which does not consider the distribution per aggregate classes, and the larger the amount of aggregates with diameter <0.25 mm, the lower the ASI.

CARPENEDO and MIELNICZUK (1990) show that soils submitted to intensive cultivation tend to loose the original structure by the fractioning of the largest aggregates in smaller units, with consequent reduction of the macroporos and increase in the microporos and density. The magnitude of the occurrence of these changes depends on the soil type and on the systems of management used; being the most harmful effect attributed to the management systems which promote the intensive revolvimento of the soil, which affects its content of organic matter, one of the main agents in the formation and stabilization of the aggregates.

LACERDA et al. (2005) analyzed the stability of the aggregates of one Nitossolo Vermelho Distroférrico[1] clay texture submitted to the management systems forest (FO), conventional preparation for ten years followed by direct sowing per 12 years (CPDS) and conventional preparation for twenty two years (CP), and verified that the substitution of the conventional preparation for the direct sowing favored the stabilization of the aggregates, even though the differences between the index of aggregation were not significant in the same depth of sampling. CASTRO FILHO et al. (1998) found significant differences between the index of aggregation in the systems of conventional and no-tillage systems, mainly in the depth 0 – 10 cm. The relative increases caused by the direct sowing were 74% for WMD, 70% for GMD and 10.4% for ASI, and they are directly linked to the higher accumulation of organic matter provided by this system in relation to the conventional sowing.

Considering the effect of the soil use and management in its structural quality, this work aims to analyze the stability of the aggregates and the degree of alteration of the physical and chemical properties of soils from the Watershed of the Ribeirão São Domingos, Santa Cruz do Rio Pardo, under different use and management systems.

Material and methods

The work was developed in the water basin of the Ribeirão São Domingos, Santa Cruz do Rio Pardo – SP (Figure 1). Its area has 8047.36 ha. This municipality has surface of

[1] Brazilian Soil Classification

1116 km² (IBGE, 2009), and the central point of the urban area has the following geographic coordinates: 22º 32′ S latitude and 49º 22′ W longitude, with mean altitude of 480 m. It is located in the Bacia Sedimentar do Paraná (IPT, 1981), in the Planalto Ocidental Paulista, in terrain with sandstone and basalt rocks (ROSS; MOROZ, 1997).

The climate is of the type Cwa (mesothermic, with rains concentrated in summer and hot summers), according to the climate classification of Köppen (MIRANDA et al., 2009). The annual average rainfall index is 1475.3 mm. The types of soil which prevail in the municipality are: Latossolos Vermelhos (LV-1), Nitossolos Vermelhos (NV-1) e Argissolos Vermelho-Amarelos (PVA-2) (OLIVEIRA et al., 1999), and the first two are found in the watershed which is objects of this work For the evaluation of the physical and chemical properties and the stability of aggregates, it was sampled soils which represent five systems of use and management, characteristic from the study area, in the depth 0 – 20 cm:

-Sample 1 – SCC – Sugarcane cultivation (22° 51′ 00″ S and 49° 39′ 25″ W): performed during thirty two years, from the crop 1977/1978, considering that the last sowing was performed in September/2004, with average of five cuttings per planting, and four cuttings until the year 2009. The soil correction is performed in the renovation of the sugarcane and before coppicing, when it is needed, considering that the last application of nitrate 23-00-18 fertilizer was performed in September 2008. In subsurface, it was applied gypsum and performed subsoiling before the planting. The harvest, application of fertilizers, agricultural defensives and other managements as mechanized. The conservationist practices adopted were: terraces, systematization of areas and installation of the vegetation corridor in a portion of the farm with highest slope and soil fragility;

- Sample 2 – PA – Pasture (22° 52′ 71″ S and 49° 38′ 96″ W): cultivation of Brachiaria brizantha, where it is developed the beef cattle from twenty seven years, and the last pasture renewable occurred twenty years ago. Pasture is fertilized two times a year with urea 2420, in alternate months, in the dry period. In period before the sampling, it was applied poultry manure.

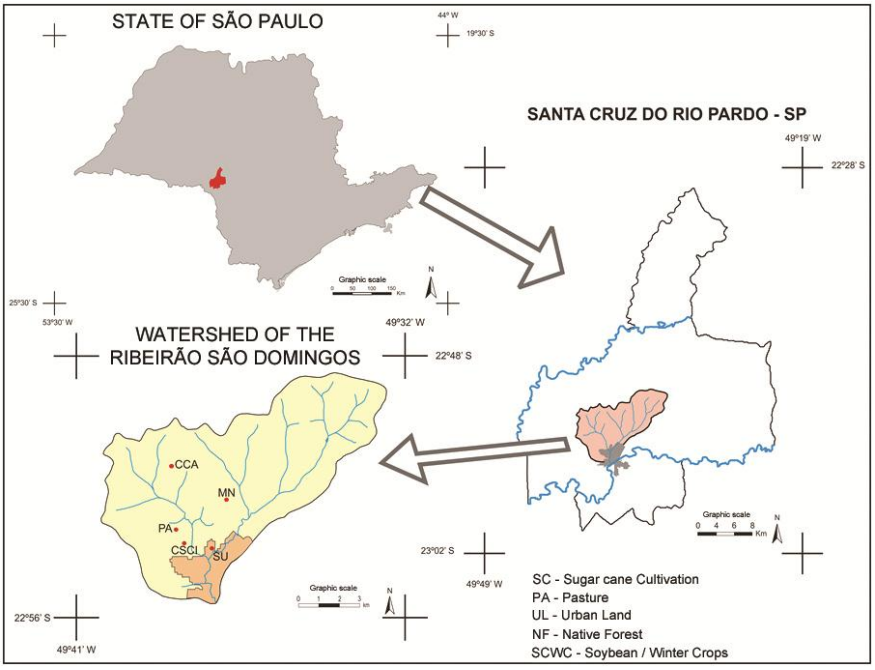

Figure 1. Location of the Municipality of Santa Cruz do Rio Pardo in the state of São Paulo, of the watershed of the Ribeirão São Domingos and of the points of soil sampling. (Organization Demarchi, 2009).

In period before the sampling, it was applied poultry manure. In the date of the sampling, there were sixty head of cattle in the property. The circulation of agricultural machines in pasture occurs during the application of fertilizers.

-Sample 3 – UL – Urban Land – residential area (22° 53′ 36″ S e 49° 37′ 97″ W): sample performed in one wasteland, located in the Parque São Jorge, residential area of low socioeconomic status, in the periphery of Santa Cruz do Rio Pardo, with rates of urbanization of 60% and forestation of 1%. It is located in the zone Z-2 (in consolidation process) in the Zoneamento Urbano do Plano Diretor do Município (PREFEITURA MUNICIPAL DE SANTA CRUZ DO RIO PARDO, 2006);

-Sample 4 – NF – Native Forest (22° 52′ 13″ S and 49° 38′ 16″ W): forest divided in the middle by the road Rodovia SP-327. It contains native species, but it suffered intervention from man, mainly in the construction of the road and for the extraction of wood with commercial aims, from approximately two decades. Even if it has secondary vegetation, the sampling was performed for aims of comparison with the other soil uses, since it presents conditions close to a natural system;

-Sample 5 – CSWC – Cultivation of soybean in rotation with winter crops (22° 53′ 16″ and 49° 38′ 53″ W): soybean is cultivated from seven years, from the crop 2002/2003, and each year it is cultivated one winter crop – it was sorghum in 2007, oak in 2008 and fallow in 2009, after the soybean harvest and the soil sampling. The preparation of the soil for the soybean plantation is conventional (one ploughing and one harrowing), and the winter crops are cultivated in a system of crop rotation, with the minimum mobilization of the soil and maintaining the cultural remains. The fertilization is performed before all the plantings, and the liming every two or three years, depending on the yield. Although the relief is wavy to strongly wavy, all the agricultural operations are mechanical. The property has terraces to contain the water erosion.

The information about the use and soil occupation, management, conservationist practices, degree of urbanization and other relevant information obtained from interviews with qualified staff.

The deformed and undeformed samples (Kopeck rings) were submitted to chemical and physical analysis. The evaluated properties were: density of the particle (flask method), soil density (volumetric ring method), Total Volume of Pores - TVP (calculated from the values of density of the particle and soil density), texture (pipette method) (EMPRAPA, 1997), index of acidity (pH in CaCl2), content of organic matter, content of phosphorus (P) – resin, content of potassium (K), calcium (Ca), magnesium (Mg) and hydrogen + aluminum (H + Al), Sum of Bases (SB = K + Ca + Mg), Cation Exchange Capacity (CEC = SB + H + Al), and Base Saturation - V%, [V = 100.(SB/T)], according to the IAC system.

The stability of aggregates was analyzed trough humid sieving of the soil samples in the Yodder apparatus, according to the method described by KIEHL (1979). The results, expressed in the classes 8 – 2 mm, 2 – 1 mm, 1 – 0.5 mm, 0.5 – 0.25 mm, 0.25 – 0.105 mm and <0.105 mm, were used in the calculation of the Weighted Mean Diameter (WMD), the Geographic Mean Diameter (GMD), the Aggregate Stability Index (ASI) and the Index AGRI (percentage of aggregates with diameter superior to 2 mm). These index of soil aggregation were calculated in the following way:

$$\mathbf{WMD = \Sigma\ (xi.wi)} \qquad \mathbf{(1)}$$

In which xi is the mean diameter of the classes (mm) and wi is the proportion of each class in relation to the total, according to YOUKER and MCGUINESS (1956).

$$\mathbf{GMD = \exp\{\Sigma[(\ln [xi]*[pi])] / \Sigma[pi]\}} \qquad \mathbf{(2)}$$

In which ln[xi] is the natural logarithm of the mean diameter of the classes and pi is the weight (g) retained in each sieve, according to CASTRO FILHO (2002).

ASI = {(W.S – wp<0,25) / (W.S)}*100 (3)

In W.S = Weight of the sample, which wp<0.25 corresponds to the weight of the aggregates of the class <0.25 mm, data in grams, according to CASTRO FILHO (2002).

AGRI = wi>2 x 100 (4)

In which wi>2 represents the proportion of aggregates >2 mm, according to WENDLING et al. (2005).

The map of land use of the watershed of the Ribeirão São Domingos was generated in the SIG Idrisi Andes from the Landsat-5 satellite image, Thematic Mapper sensor, orbit-point 221/76, false-color composition 543 from 04-05-2005, through the method of screen classification. For the update of the land uses, it was performed field work in pre-determined places.

Results and discussion

The aggregation and stability of the soil aggregates is function of some of its physical and chemical properties, mainly the organic matter, the minerals of clay and the oxides of iron and aluminum. As the soil use and management, either in the agricultural or urban area, provide changes in these properties, they are responsible for the higher or lower stability of their aggregated to the action of rain, wind and mechanic forces, as those used in the soil preparation. Therefore, in order to evaluate the stability of aggregates of the soil uses, it is necessary to characterize them physically and chemically. Table 1 presents the values of soil density, particle density and total volume of pores of the soils analyzed, and Table 2, the results of the texture analysis.

Table 1. Bulk density, Particle density and Porosity in different land use systems.

Land use system	Bulk density	Particle density	Porosity
	Kg dm^{-3}		%
Sugarcane Cultivation (SC)	1.58	2.41	35
Pasture (PA)	1.41	2.33	39
Urban Land (UL)	1.56	2.30	32
Native Forest (NF)	1.07	2.38	51
Soybean / Winter Crops (SCWC)	1.30	2.74	49

Table 2. Textural analysis of soil samples in different land use systems.

Land use system	Sand	Loam	Clay	VT	T	M	TH	VTH	Textural class
		g kg^{-1}		g kg^{-1}					
SC	494	99	407	65	299	116	11	3	Clay
PA	280	123	597	40	151	73	14	2	Clay
UL	367	107	526	78	213	66	7	3	Clay
NF	360	139	501	56	209	82	13	0	Clay
SCWC	224	280	496	60	110	42	10	2	Clay

Sand fractionation: VT: very thin; T: thin; M: medium; TH: thick; VTH: very thick

Table 3 presents the values of the chemical properties in the systems of land use analyzed in this work.

Table 3. Soil chemical properties in different land use systems.

Land use system	pH em $CaCl_2$	O. M.	P resin	K	Ca	Mg	H+Al	SB	T	V
		g dm^{-3}	mg dm^{-3}	$mmol_c$ dm^{-3}						%
SC	5.2	28	5	0.8	35	15	34	50.8	84.8	60
PA	4.9	31	4	1.1	18	7	38	26.1	64.1	41
UL	4.0	16	3	1.8	4	2	47	7.8	54.8	14
NF	5.0	32	6	1.7	20	10	34	31.7	65.7	48
SCWC	6.4	32	14	0.8	78	70	15	148.8	163.8	91

The soil under the use of SCC (Sugarcane cultivation) presented high soil density and low total volume of pores (Table 1), if its clayey texture class with prevalence of the sand fraction is considered (Table 2). These conditions are due to the traffic of machines used in the agricultural operations, to the small soil mobilization, since the sugarcane crop was renewed five years ago, and to the low content of organic matter, which promotes aggregation and increase in the soil porosity. In relation to chemical attributes, it is noteworthy the base saturation of 60% and the relatively high pH (Table 3), mainly due to the application of gypsum, which is source of calcium and promotes the increase of its cation exchange capacity.

The pasture areas (PA) presented soil density inferior to the use SCC (Table 1), highest, considering the interval proposed by KIEHL (1979) for soils with clayey texture (1.0 a 1.25 kg.dm-3), and consequently, low total porosity, due to the traffic of agricultural machines for the fertilization, cattle trampling and absence of mobilization of pasture, which was renewed twenty years ago. From the viewpoint of the chemical properties, it presents content of organic matter of 31 g/dm^3 in function of the decomposition of the roots of *Brachiaria brizantha* (Table 3), of the animal manure (cattle and poultry), but it presented low base saturation, inferior to 50%, and lower pH, due to the absence of management with basic cations.

The soil located in the urban area (UL) has its original properties weakened due to the intervention of man to the urbanization. With clayey texture (Table 1), this soil is compacted and with very low total porosity (Table 2), ideal condition for the civil construction, but bad from the viewpoint of its conservation as natural resource. It still presents negligible content of organic matter, pH extremely acid and low CEC and base saturation (Table 3). The low content of organic matter is according which was estimated by DALMOLIN et al. (2006) for urban soils, but the pH contravenes their estimate, since the residues of the construction material present alkaline pH.

The area of native forest (NF) present the best physical conditions among the studied land uses, with soil density 1.07 kg dm-3 and total porosity of 51% (Table 1). This condition is a result of the preservation of the natural characteristics by the small interference of man and by the action of organic matter present in roots, in serrapilheira (layer with accumulation of cultural residues and organic matter) and in the soil fauna. Considering the chemical attributes, it presented low pH (high acidity), and base saturation of 48% (Table 3), mainly due to the non-addition of fertilizers, as there is in agricultural areas. It is important to emphasize that tropical soils are naturally acid due to the process of leaching.

The system of cultivation of soybean and rotation with winter crops (CSWC), from clayey texture (Table 2) and with higher density

of particle among the analyzed soils (2.74 kg dm-3), had soil density a little higher than the superior appropriated limit of soil density for clayey soils, and total porosity close to the ideal composition of the soil (Table 1). These characteristics are due to the soil management, with incorporation of the soybean cultural residues for the sowing of winter crops, and to the preparation of the soybean cultivation, which breaks the superficial sealing and the compacted layer. Due to the fertilization, performed annually in the soil preparation, and to the liming, performed every two or three years in the same period, the considered system of management presented high content of calcium and magnesium, high sum of bases and base saturation classified as high (GARGANTINI, 1966 cited by FREIRE, 2006), besides very high CEC (Table 3), superior to the maximum value expected for kaolinitic soils, i.e., it presents high availability and capacity of nutrient exchange, superior to the attributes of the use NF, which enables to infer that the correct soil management promoted the improvement of the physical and chemical properties.

Table 4 presents the values of the index of stability of aggregates of the soils analyzed.

Table 4. Mean Weight Diameter (MWD), Geometric Mean Diameter (GMD), Aggregate Stability Index (ASI) and AGRI Index in different land use systems.

Land use system	MWD (mm)	GMD (mm)	ASI (%)	AGRI (%)
Sugarcane Cultivation (SC)	1.619	0.601	64.64	25.84
Pasture (PA)	4.121	2.961	92.88	79.72
Urban Land (UL)	0.572	0.264	45.32	4.20
Native Forest (NF)	3.434	2.039	88.44	63.72
Soybean / Winter Crops (SCWC)	1.963	1.037	85.32	26.72

The analysis of the index of stability of the aggregates by humid sieving of the Table 4 enables to order the systems of land use in the following decreasing order of aggregation and structural quality: Pasture (PA), native forest (NF), cultivation of soybean in rotation with winter crops (CSWC), sugarcane cultivation (SCC) and Urban Land (UL). Relating the AGRI index, which evaluates the percentage of aggregates with diameter superior to 2 mm, with other index of soil aggregation, it is concluded that the higher the percentage of aggregates retained in the class 8 – 2 mm, the higher the aggregation will be and the stability of these aggregates, and the lower will be their susceptibility to water erosion.

Table 5 presents the distribution of the aggregates of the analyzed soils in classes of size, with values expressed in percentage.

Table 5. Distribution of soil aggregates (%) in size classes.

Size classes	SC	PA	UL	NF	SCWC
8 - 2 mm	25.84	79.72	4.2	63.72	26.72
1 - 2 mm	7.92	5.6	7.92	10.04	30.12
0.5 - 1 mm	11.12	4.0	12.12	7.48	13.12
0.25 - 0.5 mm	19.76	3.56	21.08	7.2	15.36
0.105 - 0.25 mm	26.12	3.16	35.8	6.76	8.96
0 - 0.105 mm	9.24	3.96	18.88	4.8	5.72

The soil with cultivation of sugarcane (SCC) presented the second lowest index of aggregation, considering that 55% of its aggregates have diameter inferior to 0.25 mm (Table 5). These results come from the content of clay from this soil (407 g kg-1), inferior to the content of sand (494 g kg-1) but, mainly, from the reduced content of organic matter and to the adopted management. The compaction of this soil, coming from the traffic of agricultural machines, the lack of protection of the surface after the annual harvest, and the low content of organic matter make it vulnerable to the action of rain, which promote the clogging of the pores and the fleck trough the impact, generating superficial drift, transport of particles and reduction of the stability of the aggregates and of the resistance to the erosive processes.

The soil under pasture (PA) has better conditions of aggregation and stability of the aggregates between the systems of soil use analyzed. The diameter estimated from the class of aggregates with higher occurrence, expressed by the WMD, is 2.961 mm; soil presents 79.72% of its aggregates with diameter superior to 2 mm, and Index of Stability of Aggregates of 92.88% (Table 4). The main factors responsible for the high stability of aggregates are: high content of clay (597 g kg^{-1}) and, consequently, high content of clay minerals; protection of the organic matter of the soil trough the vegetal cover against the degradation by the impact of rainfall and abrupt variations of humidity; providence of energy of the organic matter for the microbial activity, which produces substances responsible for the formation and stabilization of the aggregates of the soil; and effect of the roots of the Brachiaria brizantha in the providence of organic matter to the soil and in the reduction of the superficial drift of the rainfall water.

This result is in accordance with the one obtained by WENDLING et al. (2005) in a Latossolo Vermelho cultivated for three years with tifton (hay) followed by one year with soybean, in no-tillage system. This behavior comes from the effect of tifton, which is a perene culture and has high relation C/N, which gives it longer time of decomposition and residence of organic matter, causing higher content of total organic carbon to the soil and, therefore, higher stability of aggregates. The stability of aggregates in the PA system is high, even with the possible compaction and reduction of their porosity, and with the low content of bivalent cations, which are important agents of soil aggregation.

The soil occupied by the Urban Land (UL) presents very low aggregation index: only 4.2% of its aggregates have diameter superior to 2 mm (Table 5), it presents ASI of only 45.32% and GMD of 0.264 mm, index which reflects the mean size of the class with higher occurrence of aggregates. The low stability of the aggregates of the humid sieving may be explained by the reduced content of organic matter and bivalent cations, responsible for the aggregation and stability of the aggregates, even though the texture is clayey (content of clay of 526 g kg-1). As a consequence, it presents high soil density and low porosity, inferior to the minimum limit of porosity for clayey soils of 40%, characteristics which contribute to the increase in the vulnerability to the erosive processes since it makes the infiltration more difficult and facilitates the superficial drift of the rainfall water.

The area with native forest (NF), sampled for the use as parameter of comparison with the other systems of land use since it is a system close to the natural, presented index of aggregation inferior to the use PA, but high aggregate stability index, i.e., WMD of 3.434 mm, AGRI index of 63.72% and ASI, which measures the overall state of soil aggregation, of 88.44% (Table 4). These results may be explained by the soil aggregation promoted by the forest roots; by the high content of organic matter, caused by the presence of serrapilheira, roots and by the soil fauna; by the dense vegetal cover, which

besides protecting soil from the impact of the rainfall, it prevents the decomposition of organic matter by sun radiation, and by the almost null anthropic action.

The system cultivation of soybean in rotation with winter crops (CSWC) presented intermediate aggregation index among the analyzed soils: only 26.72% of its aggregates have diameter superior to 2 mm (Table 5), and the mean size of the class with higher occurrence of aggregates, expressed by GMD, is 1.037 mm (Table 4). Although the content of organic matter presented by this soil is relatively high, in comparison to the other uses, the content of calcium and magnesium, aggregating agents of the soil, are classified as "high" (BUENO et al., 2007), the soil mobilization in the preparation for the soybean sowing, with ploughing and harrowing, and the traffic of machines in the agricultural operations, may have promoted the spraying of aggregates with bigger size. It is still emphasizes that the sampling was performed forty days before the soybean harvest, when the soil was protected by the aerial part of this crop.

The map of land use and occupation of the Watershed of Ribeirão São Domingos (Figure 2), relative to the month of February/2009, points the predominance of the sugarcane cultivation (36.7% of the total area), pasture (31.5%), riparian area (8.4%), areas with exposed soil, as a preparation for the cultivation (6.9%), urban area (6.1%) and areas with native forest (4.1%).

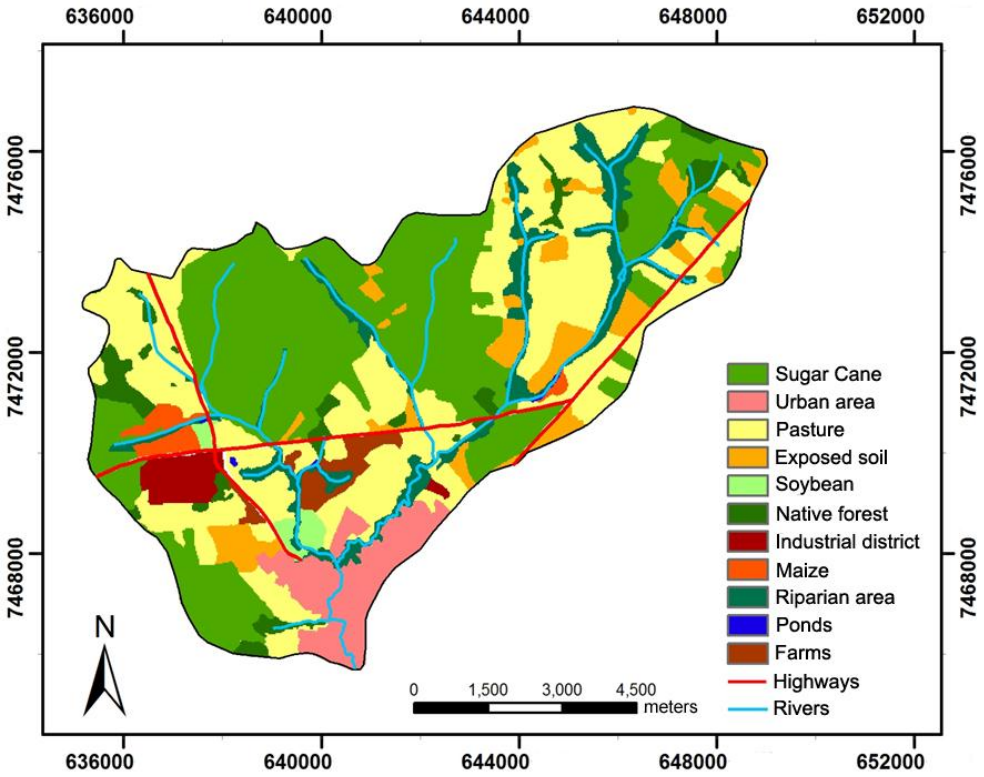

Figure 2. Map of land use and occupation of the Watershed of Ribeirão São Domingos Elaboration: Demarchi and Piroli (2009)).

The analysis of the map, related to the concept of water basin and its natural dynamics, enables to emphasize the necessity of adoption of cultivation and management system in order to conserve the agricultural soils, mainly in the crops with larger occupation, as sugarcane and pasture. It is necessary also an efficient order of the urban soil, which would promote the improvement of its structural quality and the reduction of the loss by erosion, aiming at the conservation of soil and water resources of the watershed. It is still emphasized the absence of riparian forest, mainly close to the water courses surrounded by sugarcane crops.

Conclusions

The analysis of the soil aggregate stability in difference use, occupation and management systems enables to verify that:

-In decreasing order of structural quality and resistance to water erosion, the analyzed land uses are thus ordered: PA (pasture), Native Forest (NF), soybean cultivation in rotation with winter crops (SCWC), Sugarcane cultivation (SCC) and Urban Land (UL). The main factors responsible for the aggregate stability were: clay, organic matter, vegetal cover and type of soil use and management;

-The use NF presented better conditions of soil porosity and density; the use CSWC had good chemical conditions and availability of nutrients to plants; the urban land (UL) has the highest degree of alteration of its physical and chemical attributes, and presents low index of aggregation;

-The soil use and management cause different degrees of alteration in its chemical and physical properties.

References

AZEVEDO, A.C.; DALMOLIN, R.S.D. **Solos e Ambiente:** uma introdução. Santa Maria: Pallotti, 2004. 100p.

BARBOSA, Z.; BAHIA, V.G.; PAULA, M.B. Atuação da biota do solo na formação e estabilização de agregados e na estruturação dos solos, influenciando o controle da erosão. **Informe Agropecuário,** v.19, n.191, p. 59-65, 1998.

BUENO, O.C. et al. **Mapa de fertilidade dos solos de assentamentos rurais do Estado de São Paulo:** contribuição ao estudo de territórios. Botucatu: FEPAF, 2007. 77p.

CARPENEDO, V.; MIELNICZUK, J. Estado de agregação e qualidade de agregados de Latossolos Roxos, submetidos a diferentes sistemas de manejo. **Revista Brasileira de Ciência do Solo**, v.14, n.1, p.99-105, 1990.

CASTRO FILHO, C. Atributos do solo avaliados pelos seus agregados. In: MORAES, M. H.; MÜLLER, M.M.L.; FOLONI, J.S.S. **Qualidade física do solo:** métodos de estudo - sistemas de preparo e manejo do solo. Jaboticabal: Funep, 2002. p.21-46.

CASTRO FILHO, C.; MUZILLI, O.; PODANOSCHI, A.L. Estabilidade dos agregados e sua relação com o teor de carbono orgânico num Latossolo roxo distrófico, em função de sistemas de plantio, rotações de culturas e métodos de preparo das amostras. **Revista Brasileira de Ciência do Solo**, v.22, n.3, p.527-538, 1998.

CHAVES, J.C.D.; CALEGARI, A. Adubação verde e rotação de culturas. **Informe Agropecuário**, v.22, n.212, p.53-60, 2001.

DALMOLIN, R.S.D.; PEDRON, F.A.; AZEVEDO, A.C. de. Modificações do solo em áreas urbanas. In: DALMOLIN, R.S.D.; AZEVEDO, A.C.; PEDRON, F.A. (Eds.). **Solos & Ambiente** – II Fórum. Santa Maria: Orium, 2006. p.9-25.

EMBRAPA. **Sistema brasileiro de classificação de solos**. 2. ed. Rio de Janeiro: Embrapa Solos, 2006. 306p.

FREIRE, O. **Solos das regiões tropicais**. Botucatu: FEPAF, 2006. 268p.

FUNDAÇÃO INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Cidades@.** Disponível em: <http://www.ibge.gov.br/cidadesat/topwindow.htm?1>. Acesso em 21abr. 2009.

INSTITUTO DE PESQUISAS TECNOLÓGICAS DO ESTADO DE SÃO PAULO. **Mapa geológico do Estado de São Paulo.** São Paulo, 1981. v.1. p.46-8; 62-78. Escala 1:500.000.

KIEHL, E.J. **Manual de edafologia.** São Paulo: Agronômica Ceres, 1979. 264 p.

LACERDA, N. B. et al. Efeito de sistemas de manejo na estabilidade de agregados de um Nitossolo Vermelho. **Engenharia Agrícola**, v.25, n.3, p.686-695, 2005.

MIRANDA, M.J. et al. **A classificação climática de Köeppen para o Estado de São Paulo**. Disponível em: <http://www.cpa.unicamp.br/outras-informacoes/clima-dos-municipios-paulistas.html>. Acesso em 21abr.2009.

OLIVEIRA, J.B. et al. **Mapa pedológico do Estado de São Paulo.** Campinas: EMBRAPA, 1999.

PERUSI, M.C. **Discriminação de Argissolos e avaliação da estabilidade de agregados por vias seca e úmida em diferentes sistemas de uso e manejo.** Tese (Doutorado Agronomia/Energia na Agricultura) – Faculdade de Ciências Agronômicas, Universidade Estadual Paulista. Botucatu, 2005. 113 f.

PREFEITURA MUNICIPAL DE SANTA CRUZ DO RIO PARDO. **Plano Diretor Participativo:** Macrozoneamento, Zoneamento Urbano e Zoneamento Rural. Santa Cruz do Rio Pardo, 2006. 43p.

ROSS, J.L.S.; MOROZ, I.C. **Mapa geomorfológico do Estado de São Paulo.** São Paulo: FFLCH-USP, 1997, p.41-2. Escala 1:500.000.

WENDLING, B. et al. Carbono orgânico e estabilidade de agregados de um Latossolo Vermelho sob diferentes manejos. **Pesquisa Agropecuária Brasileira**, v.40. n.5, p.487-494, 2005.

YOUKER, R.E.; McGUINNESS, J.L. A short method of obtaining mean weight-diameter values of aggregate analyses of soils. **Soil Science**, v.83, n.4, p.291-294, 1957.