VALIDATION OF A PHOSPHORUS INDEX APPLIED TO A WATERSHED BY GEOPROCESSING TECHNIQUES

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INTRODUCTION

Currently the crisis of the water has been aggravated due to series of factors that from climatic questions and geographic to politics. As Tundisi (2000) the quality of the water is grown worse quickly, threatening the suppliment sources. There are many causes for this crisis, but among them the most frequently cited are the increase of the urbanization tax, that increases the necessity of multiple usages of the water, the population increase, that consumes more resources and needs bigger agricultural area for its maintenance, and the biggest demand for energy and industrialized processes. Although the neo-maltusian vision has been criticized for many authors is undeniable that population increase generates greater necessity of use of agricultural ground. Until the second half of century XIX the crises were related to the bad quality of the water due the lack of basic sanitation. In the second half of century XX, the main problems were related to the contamination of the water with toxic elements, many of them caused by agricultural activity (Tundisi, 2000, Bertuol, 2001).

The conditions that the soils are used in a watershed present a narrow relation with the quality of the water that is drained to the rivers, lakes and the reservoirs in this watershed. Thus, the more intense is the usage for this ground, either for agricultural activities or for the urbanization; greaters will be the impacts on the quality of the water. This occurs because of the depluvio derived from these areas carries a much bigger amount of pollutants when compared with the depluvio proceeding from a forest or a native field. The presence of nutrients, as phosphorus and the nitrogen, in the water in larger concentrations than the normal levels may cause the eutrophycation of water bodies and, then, favour the growth of plants and algas of the aquatic environment, provoking a disequilibrium with negative consequences for the usage of these water bodies. This effect has been pointed currently as the main form of contamination and disruption in the purification capacity of the hydrological cycle.

The excess of phosphorus in water bodies is attributed to pollutant loads derived from the launching of industrial, domestic and agriculturist effluents (dejects of animals in confinement) or the load of diffused pollution proceeding from areas under culture. In the case of the diffused pollution it becomes difficult the identification of the sources and, consequently, the application of reduction providences for its control. However, it would be reasonable to assume that in the areas where the culture is characterized by applications of phosphorus in high dosages, either by chemical or organic fertilizers, the concentration of phosphorus in the originary depluvio of these areas presents a very high risk of water contamination.

On the other hand, it is considered that most of the present phosphorus in the depluvio is in particulate form, in other words, mixed with the sediments. So it is deduced that the presence of sediments in superficial depluvio, and consequently the amount of phosphorus carried to the water, is larger in watersheds that present high levels of erosion. The risk of contamination represented for the phosphorus also depends, beyond the cited factors already, the proximity of the sources of contamination to the water bodies. It is verified then that the identification of areas of risk of contamination for phosphorus in agricultural watersheds depends on the combination of some factors. Thus the areas with potential greater of contamination will be those where factors are agreed as high concentration of phosphorus in the soil, raised risk of erosion and proximity of a water body it is probable that this area presents a high potential risk of contamination for phosphorus. Distinct condition to this example could be of one another area that also presents high concentration of phosphorus in the soil, however, if it finds of a water body distant.

The process of contamination of a water body is therefore a complicated process, that stops being shaped or understood it demands the understanding of all the involved variable. Geographic information systems (GIS) allow to the compilation and analysis of very complex scenes and wide scale, what it would be impossible to be made without the use of computational tools (Silva, 1998).

Considering all these factors a way has been proposal to identify areas of bigger risk of contamination for phosphorus in watersheds through indicating indices of risk areas. They are the P-index and initially had been considered by Lemunyon and Gilbert (1993) and later modified by Eghball and Gilley (2001). The evaluation of this method was carried through by Sharpley (1995) that it applied the method of the P-index in different watersheds where the erosion and the total phosphorus had been measured and found a good relation among these two factors. In Brazil reference to the use of this method for determination of areas of risk of contamination for phosphorus in watersheds does not consist in literature. However, problems of algae development in reservoirs have been evidenced with great frequency, what it justifies its use to assist in the identification of areas of risk for ends of integrated planning of watersheds. This work had as intention to adapt the usage of the P-index to be applied in the watershed of a system of reservoirs in cascade in the south region of Brazil

MATERIALS AND METHODS

The P-index was applied in a located watershed in San Francisco de Paula municipality, Rio Grande do Sul, of 52,48 km2 referring to the made use reservoirs Divisa, Blang and Salto in cascade, the watershed of the Caí River. These reservoirs integrate the Sistema Salto de Hidrelétricas.

The index of risk of phosphorus considered in this work was composed for three considered factors important to compose a phosphorus index, as suggested for Lemunyon and Gilbert (1993). Thus, availability of phosphorus in the soil, soil loss and contributing distance are the considered factors important to compose an index where if one weight bigger attributed to the factor erosion. To each one of the factors one attributed different class represented for numerical values that had varied of zero the eight as in table 1. For acquisition of the index of phosphorus risk the three factors had been multiplied and with this a numerical value was gotten. The transformation of the numerical value to an index of phosphorus risk was determined in accordance with table 2.

Table 1: Factors used in the index of phosphorus risk and its respective classes

Site characteristic / Unit	Class				
	None 0	Low 1	Medium 2	High 4	Very high 8
Soil loss(Mg ha^{-1}) (1,5)	0	0,1-0,5	0,6-1,0	1,1-1,5	>1,6
Contributing distance (m) (1,0)	>150	150-100	100–80	80-50	<50

Site characteristic / Unit	Class				
	None 0	Low 1	Medium 2	High 4	Very high 8
P fertilizer rate (mg L^{-1}) (1,0)	-	1,1-4,0	4,1-6,0	>6,1	>8,0

Table2: Class interval of P-index

Class	Variation
None	0 – 0,1
Low	0,2 – 0,5
Medium	0,6 – 12,0
High	12,1 – 144
Very high	144,1 - 768

The acquisition of the factors used in the composition of the index was made in agreement to the following procedures:

“Soil loss” factor:

The factor soil loss was gotten through the use of the Universal Soil Loss Equation (ULSE) associate to the one Geographic information systems (GIS).

Due to lack of factor rain erosivity for San Francisco de Paula municipality, it was used in this work, the value calculated for the Vacaria municipality for Scalabrin et al. (1994), for being municipality of a similar and next altitude the San Francisco. The value of used was then, 5565 MJ mm/ha h year. The factor soil erodibility was calculated through the equation proposal for Denardin et al. (1991), getting a 0,0494 value of t ha h/ha MJ mm.

Factor slope length and steepness of the EUPS was calculated using the USLE-2D software that was validated by Pante et al. (2002) to be used in the calculation of factor slope length and steepness of watersheds.

The factor soil cover and management was determined accordant each cover of soil pertaining of watershed, accordant Wishmeier & Smith (1978). The soil cover in the watershed was determined using images of satellite (TM – LANDSAT, bands 3,4 and 5) inside of an environment GIS through a supervised classification.

Already for factor conservation practices was considered not adoption of practical conservation in all watershed e, therefore, value 1,0 for this factor is attributed.

"P fertilizer rate" factor:

These levels had been gotten through the analysis of samples soil that they had been collected in different areas of the watershed of form to represent the different found class of use in the watershed. For determination of the concentration of phosphorus in the samples the method Mehlich I was used (Tedesco et al., 1995). Through the association of the matrix of soil usage with the level of phosphorus found in each class it was possible to determine the level of phosphorus in the different soil uses in the watershed.

"Contributing distance" factor:

The calculation of the distance to the draining net was made from a zoning of the study area, thus, got a plan of information (PI) in the form of thematic matrix, with resolution 30x30m, in Spring software. This matrix was transformed into numerical through the LEGAL language and after sliced. For each interval, a value was attributed, as table 1. These values had been adapted of Weld et al. (2002).

Phosphorus index attainment:

The index of risk of contamination for phosphorus was gotten through the multiplication of the thematic matrices: soil loss, Contributing distance and the P fertilizer rate that resulted in one fourth thematic matrix that was classified in agreement the class presented in table 2, with this, got a map of risk of contamination for phosphorus of the studied watershed.

RESULTS AND DISCUSSION

From the classification of the analyzed image of satellite and the research of field, were verified that the current soil usage in the watershed is constituted basically by areas of natural field, forestation, it forest native, and small agricultural areas distributed as the percentages presented in Figure 1, where if it verifies that more than 74% represent the areas of natural field and only 1.26% the agricultural areas.

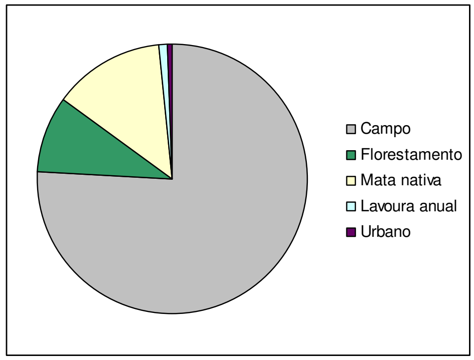

Figure 1. Soil usages in the watershed of the Sistema Salto de Hidrelétricas and its respective areas.

The tenors of P, for the different class of soil usage, inside represent an average of different areas with the same class of usage. The results showed that areas with natural field and forestation present a very low level of phosphorus in the ground (ROLAS, 1994), while the area of native forest presents a low level of phosphorus in the ground. These low levels can be explained by the fact that these are systems that possess low natural fertility of ground and in which nutrients are practically not applied by fertilization.

The areas with annual farming present high tenor of phosphorus in the soil, because the cultures adopted in the dominant agricultural system in the study region are highly fertilizer demanders. Moreover, as it can be observed in the region, most of the agriculturists does not use laboratory analyses to carry the calculus of the fertilizer necessity. Rare samplings and posterior analysis in laboratory of ground are carried through to know the real necessity of nutrients for the culture, and so, many times it is overestimated the amount of fertilizer applied in these areas, besides conservacionistas actions in the soil with farmings are not being adopted. This evidence strengthens the all system vision that the contamination of the water reaches the agricultural areas. Beyond the physical factors already related, this factor indicates a clear influence of the knowledge level and technological adoption of the agriculturist in the process of contamination of the hydric courses.

With the confection of the map of soil losses, could verify that most of the area of the watershed possesss low soil loss due, mainly, to the soil usage to be constituted essentially by natural field, that provides a good covering of the ground during the majority of the months of the year, associated to the topography that presents a soft relief. Already the areas of bigger soil losses are associates with the areas cultivated with annual cultures. These systems, as were possible to verify in field are characterized by the intense work of the soil carried through during the plantation and by not the use of practical adjusted of soil management and conservation. The combination of these factors favors the processes of runoff in consequence and the soil losses. The index of phosphorus constructed from the described factors in the paragraphs above and more in the contributing distance made possible the elaboration of the map presented in figure 2 that it represents the potential risk of contamination for phosphorus for watershed of the Sistema Salto. Through this map it is verified that the area of the watershed in study revealed, predominantly, of low risk of contamination for phosphorus. This can be explained by the fact of that most of the area of the watershed is constituted by natural field, a system characterized for not receiving nutrients saw fertilization, besides possessing low a shown natural fertility.

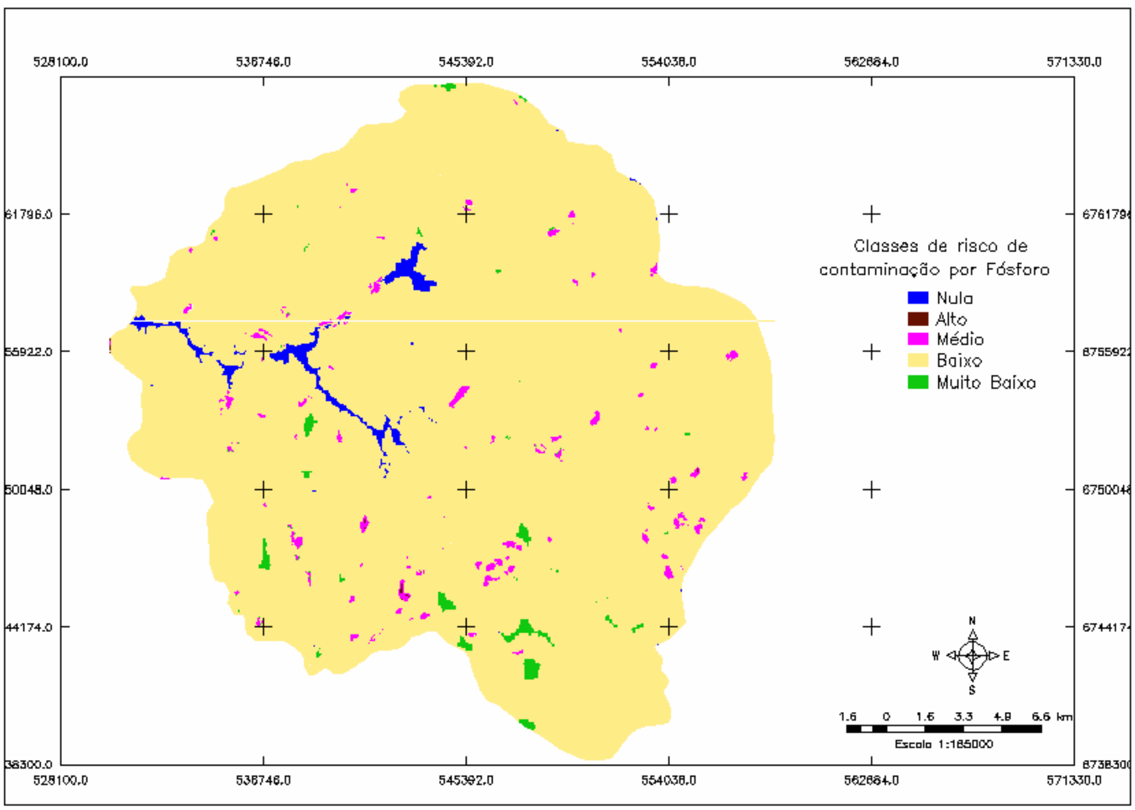

Figure 2. Map of the potential risk of contamination for phosphorus in the watershed of the Sistema Salto.

The areas of bigger risk of contamination found in the watershed are associates to the culture systems highly fertilizer plaintiffs. The use of fertilizers conditions that the soil of the areas submitted to the culture present greaters values of presented phosphorus. Associated to this aspect, it is also verified that they are the same areas under culture that present greaters resulted soil losses as gotten by the ULSE. However one perceives that only those next areas to the contributings are pointed as of bigger index of phosphorus risk, what it very represents a small percentage when compared with the total area of the watershed.

CONCLUSION

The results indicate clearly that low intensity of use that is being submitted to the watershed of the Sistema Salto, represented for the class of use with natural field and reforestation has been adjusted to keep the quality of the water of the reservoirs. However the future of these areas is preoccupying a time that the low financial returns that come occurring with the cattle one has stimulated the cattle breeder to lease its lands for agriculture, in special for vegetable tillage, as potato and garlic. One knows, however, that these cultures are highly fertilizer plaintiffs and that they offer to high risks of soil loss had to the intense soil management practiced in these tillages. This would be a grandiosity question to be debated with the committees of watersheds a time that if creates a conflict enters the necessities to preserve the watersheds of the reservoirs to keep the quality of the water and the economic necessities of the agriculturists who takes to the changes of soil usage almost always guided for conditions of more intensive use e, therefore, that they offer to high risks for degradation of the hydrics resources.

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