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CHARACTERIZATION OF GEOCHEMICAL PARAMETERS OF AN ORGANIC SOIL FROM TERRA DE AREIA, NORTHERN COASTAL PLAIN, RIO GRANDE DO SUL, BRAZIL.

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ABSTRACT

Sixteen samples of organic soil from a wetland, collected at a depth of 0.30 m, at a distance of 4 km from the town of Terra de Areia in the Northern Coastal Plain of Rio Grande do Sul were analyzed and studied, for the presence of various metals, nitrogen, phosphorus, organic carbon, sulfur, humidity, ashes and heat content. The exact location of the sampling corresponds to Latitude 29°33'04''S; Longitude 50°03'25''W. On the basis of the experimental results obtained for organic carbon, ash and heat content it may be concluded that the site is not a turfland. On the other hand, metal and flux analysis gave information about the evolution of the site and may be important from an ecological viewpoint.

Keywords: Turfland, Wetland, Soil Samples, Geochemical Analysis.

RESUMO

Dezesseis amostras de solo orgânico, provenientes de um banhado, coletadas a 0,30 m de profundidade, localizado numa distância de aproximadamente 4 km da cidade de Terra de Areia, Planície Costeira Norte do Rio Grande do Sul, foram analisadas e estudadas, em relação a presença de vários metais, nitrogênio, fósforo, carbono orgânico, enxofre, umidade, cinzas e poder calorífico. A exata localização da amostragem, corresponde a Latitude 29°33'04''S; Longitude 50°03'25''W.

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Com base nos resultados experimentais obtidos para carbono orgânico, cinzas e poder calorífico, pôde-se concluir que o local não corresponde a uma turfeira. De outro modo, as análises de fluxo de metais trazem importantes informações sobre a evolução do ambiente a partir de um ponto de vista ecológico.

INTRODUCTION

The lack of major integrated studies of environmentally protected areas in Brazil, involving botany, zoology, geography, geology and chemistry has led to bad uses of large areas of land. Mismanagement and lack of law enforcement have resulted in the destruction and abandonment of vast areas of Mata Atlântica (Atlantic Rain Forest), an important sanctuary of many species.

In order that such environments that we have inherited from nature may be available to future generations it is imperative that they be studied interdisciplinarily and preserved.

Wetlands and turflands contain a very rich biodiversity, but it is very susceptible to environmental changes. The great majority of studies done so far were in the Northern Hemisphere (Finland, Soviet Union, United States, Canada) and dealt with ecological ralationships, energetic or agricultural potentials[1].

In Brazil, the first significant studies were done by Villwock and coworkers[2] in 1979 and concerned geochemical characterization of the deposit of Águas Claras in the city of Viamão, Rio Grande do Sul. In the same year, the Instituto de Pesquisas Técnicas - IPT of the State of São Paulo published a report on studies done with turf, particularly analysis of hydrogen, nitrogen, oxygen, ashes, organic matter, carbon and some metals[3].

In 1981 Lemos and coworkers studied some turf deposits from the state of Paraná and discussed heat content, sulfur and acidity[4]. Lima and his coworkers published in 1982 an energetic characterization of turf from the Brazilian Coast in the states of Bahia and Sergipe and reported results for humidity, heat content and sulfur[5]. In 1983 Füller[6] studied the possible energetic use of peat from Salvador, Bahia; Campos, Rio de Janeiro and São José dos Campos, state of São Paulo. In 1985 Kiehl[7] reported results of nitrogen and pH studies in peat from the state of São Paulo. SANTOS[8] measured physical-chemical parameters and age of humic acids for peat from the margins of the Mogi-Guaçu River, state of São Paulo. In 1989 Roth[9] analyzed palinologically turf from the Parque Nacional de Aparados da Serra, Cambará do Sul, state of Rio Grande do Sul. In 1991 Neves[11] published results of a palinologic study in the region of Terra de

Areia, state of Rio Grande do Sul and also gave a detailed botanical and geological description of the site studied.

The purpose of the present work is to perform a geochemical characterization of organic soils from a wetland in Terra de Areia, Northern Coastal Plain in the state of Rio Grande do Sul and to obtain a better knowledge of this ecosystem.

DESCRIPTION OF THE SITE

The site under consideration is situated in town of Terra de Areia, Northern Coastal Plain in the state of Rio Grande do Sul, Brazil. It consists of a wetland located in a filled depression of an old pleistocene beach ridge near the volcanic rocks of Serra Geral Formation (Lat. 29°33'04''S; Long. 50°03'25''W). A geologic map of the microregion is given in Figure 1. The extremities of wetland are surronded altered sand fields that represent the higly eroded crests of an old pleistocene beach ridge.

CLIMATE

The climate of the Northern Coastal Plain of Rio Grande do Sul is generally considered mildly mesothermic and very humid[10]. According to data provided by IPAGRO[16] the average annual temperature is 19.8°C. In January, the hottest month of the year, the average is 24.4°C, whereas in June, the coldest month, it is 15.4°C. The mean annual relative humidity is 79 per cent and the mean annual precipitation is 1676.5 mm. There are about 123 rainy days per year. The evaporation rate is 1094.1 mm/yr. The winds are mainly southeasternly and at times southwesternly with an average velocity of 20 m/s. Because of the proximity of the Serra Geral Formation, rain storns are common, due to hot air masses that come from the Atlantic Ocean and reach the slopes of the mountains. The climatic conditions explain the hydric excess and importance of the rain for the maintenance of the hydrographic conditions of the site and the development and maintenance of the ecosystem and low land vegetation of the region.

VEGETATION

A general view of the site under consideration is given in Figure 2 and some typical local vegetation is shown in Figure 3. The vegetation of the microregion can be considered of three basic types: a forest with tropical characteristics, a wetland and an altered sandy terrain. A

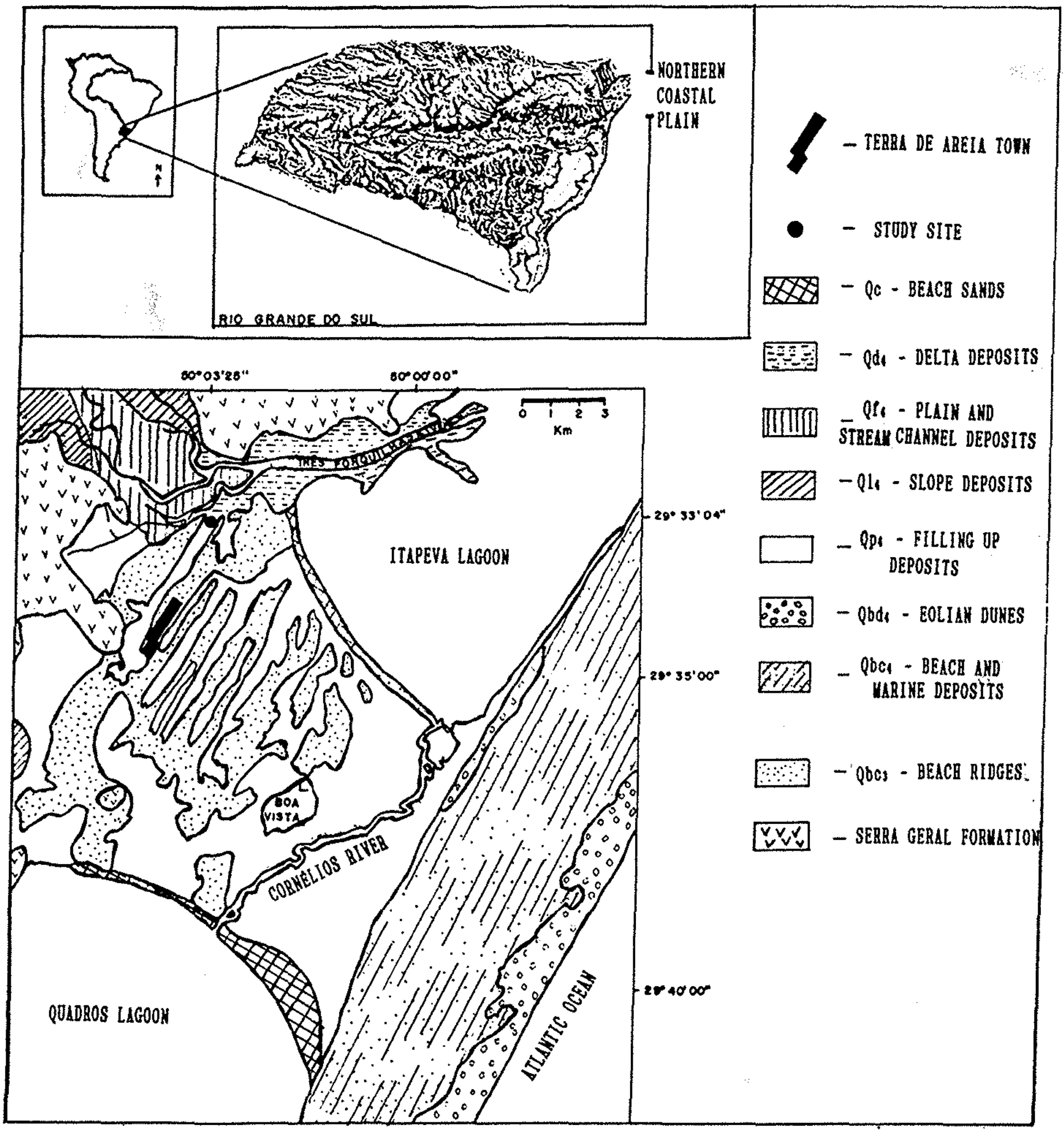

FIGURE 1. GEOLOGIC MAP OF THE MICROREGION STUDIED (ACCORDING NEVES AND LORSCHEITTER[12]).

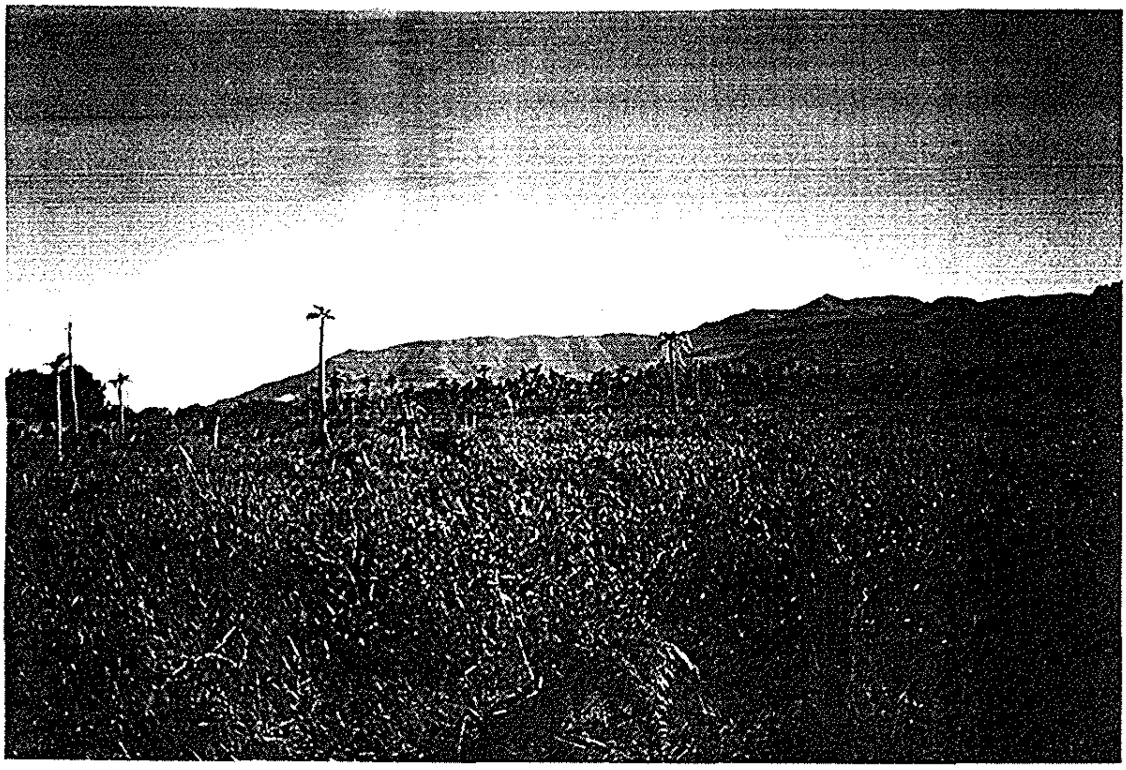

FIGURE 2. GENERAL VIEW OF THE SITE STUDIED (SERRA GERAL FORMATION IN THE BACKGROUND Qp_4 FACIES).

FIGURE 3. SOME ASPECTS OF THE VEGETATION OF THE MICROREGION STUDIED (Qp_4 FACIES).

detailed description has been given by Neves and Lorscheitter[13].

The forest contains a large number of tropical species including: *Rodriguezia decora* Rchb. f. and *Pleurothallis spp.* (Orchidaceae); *Vriesea rodigasiana* E. Morr., *Nidularium innocentii* Lem. and *Tillandsia usneoides* (L.) L. (Bromeliaceae); *Philodendron aff. imbe* (Schott) Schott (Araceae); *Geonoma schottiana* Mart., *Bactris lindmaniana* DR. and *Syagrus romanzoffiana* (Cham.) Glassm. (Arecaceae) and *Smilax quinquenervia* Vell. (Smilacaceae).

Close to the forest there is swampy portion without trees containing: *Spagnum spp.* (Spagnaceae); *Scirpus cf. giganteus* Kunth (Cyperaceae); *Baccharis spp.* (Asteraceae); *Leandra australis* (Cham.) Cogn. (Melastomataceae); *Syngonanthus crysanthus* (Bong.) Ruhl (Eriocaulaceae); *Schizachyrium sp.* (Poaceae); *Ilex pseudobuxus* Reiss. (Aquifoliaceae); *Gomidesia palustris* (DC.) Legr. (Myrtaceae); *Vernonia puberula* Less. (Asteraceae); *Ludwigia caparosa* (Camb.) Hara (Onagraceae); *Syagrus romanzoffiana* (Arecaceae) and *Coussapoa microcarpa* (Schott) Rizz. (Cecropiaceae).

To the north there is a wetland formed by the delta system of Três Forquilhas River. This wetland is characterized mainly by the presence of aquatic macrophytes such as: *Pontederia lanceolata* Nutt. and *Eichhornia azurea* Kunth (Pontederiaceae); *Sagittaria montevidensis* (L.) Cham. *et* Schlecht. (Alismataceae); *Senecio bonariensis* Hook. *et* Arn. (Asteraceae); *Ludwigia caparosa* (Onagraceae); *Myriophyllum brasiliense* Cambess. (Halorragaceae); *Eryngium pandanifolium* Cham. & Schelecht. (Apiaceae) and *Azolla spp.* (Azollaceae).

The altered sandy terrain that is higher (Qbc_3 facies) contains: *Eriochrysis cayennensis* Beauv., *Andropogon bicornis* L. and *Briza erecta* Lam. (Poaceae); *Sida cordifolia* L. (Malvaceae); *Asclepias curassavica* L. (Asclepiadiaceae); *Lantana camara* L. (Verbenaceae); *Pteridium aquilinum* (L.) Kuhn (Dennstaedtiaceae); *Bidens pilosa* L., *Baccharis spp.*, *Hipochaeris sp.*, *Orthopappus angustifolium* Gleassun and *Simphyopappus casarettoi* B. L. Robynson (Asteraceae); *Desmodium ascendens* (Sw.) DC. (Fabaceae); *Dodonaea viscosa* Jacq. (Sapindaceae); *Mimosa bimucronata* Kuntze (Mimosaceae); *Jacaranda puberula* Cham. (Bignoniaceae); *Butia capitata* Becc. (Arecaceae) and *Pseudobombax grandiflorum* (Cav.) A. Robyns (Bombacaceae), and other cultivated species.

GEOLOGICAL DATA

The town of Terra de Areia, where the site under study is located is according to Villwock[14] part of the Coastal Geologic Province of Rio Grande do Sul. The geological mapping contains the Qbc_3 and Qp_4 facies. The Qp_4 facies, where the samples for the present study were collected contains a lagoon and fluvial deposits that came to fill the pre-existing depressions among the crests. The elastic particles of these deposits are generelly rounded with medium sphericity and smooth polished surfaces. They contain quartz, muscovite, chalcedony, feldsdpar, a small quantity of heavy minerals and significant amounts of organic matter[17]. Along the Northern Coastal Plain this facies is many times related to peat and clay deposits. These mire deposits of the area seem to be related to former lagoon land forms and never attain a large superficial extension. They originated from a progressive filling of isolated lagoon bodies in old beach ridge depressions. Results of ^{14}C dating by NEVES[11] show that the begining of the sedimentation of these deposits date to 23,800 ± 500 yrs B. P., corresponding to the last glacial stage of the Pleistocene.

MATERIAL AND METHODS

The choice of the study site took into acconnt primarily the good environmental preservation of the medium and the presence of organic soil adequate for analysis. The main purpose was to obtain analytical data free of external interference.

Sixteen different samples of organic turf soil were collected at a depth of 0.30 m and at distances of about 20 m between the various sampling points. The samples were collected on May 3, 1995. In a previous study dealing with the sedimentological characterization we have shown that superior horizon of the wetland has the most pronounced turf characteristics[12]. A diagram illustrating the collection points at the site is shown in Figure 4.

In order to obtain representative samples for analysis and correct for edaphic variations the sixteen samples were subdivided in to two groups and designated 1A to 8A and 1B to 8B, respectively.

Samples 1A to 8A were analyzed in the COPESUL Laboratoty in Triunfo, RS. They were dried for approximately 16 hours until reaching a constant weight. The samples were then digested with nitric and hydrochloric acids. The analysis for metals was performed using a Plasma ICAP Spectrometer. The analysis for ash content was done by heating at 750°C for one hour followed by mass difference. The hygroscopic humidity and the heat content were determined at 105°C according to standard methods described for mineral coal following Brazilian Norms (ABNT - MB15).

Samples 1B to 8B were dried to a constant weight at 40°C and subsequently analyzed in the Soil Chemistry

Laboratory of Universidade Federal do Rio Grande do Sul in Porto Alegre.

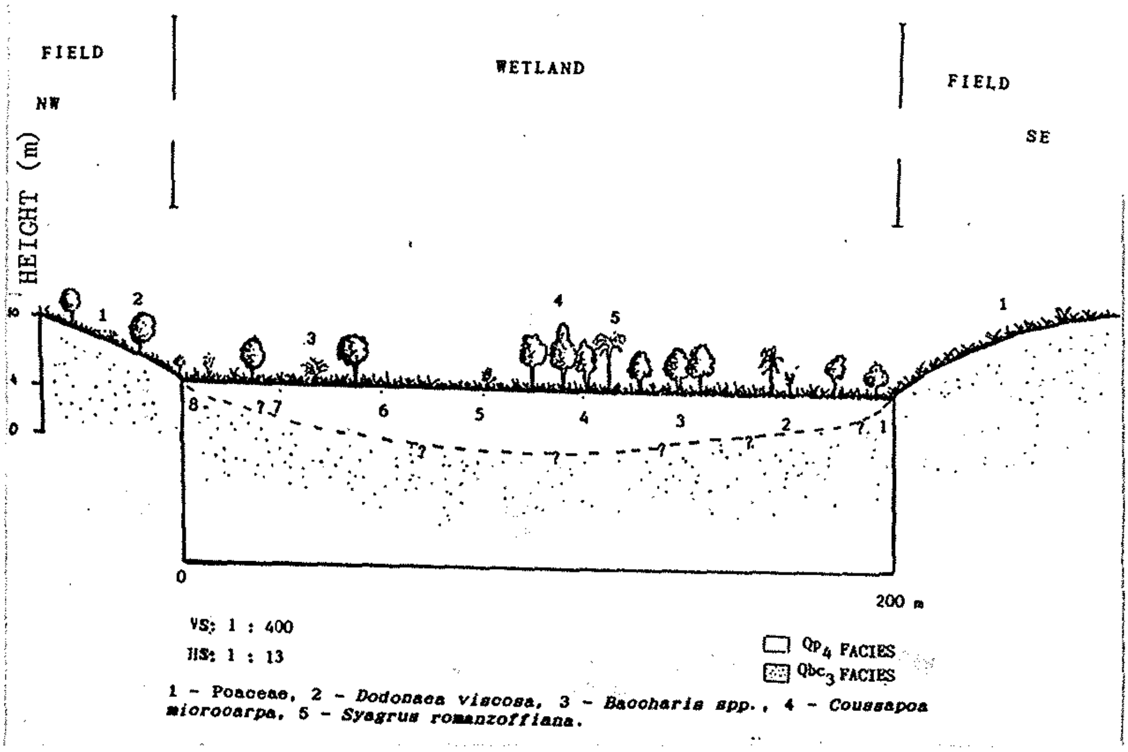

FIGURE 4. DIAGRAM ILLUSTRATING SAMPLING POINTS AT THE SITE STUDIED.

They were subjected to mechanical milling prior to analysis and digested with hydrogen peroxide and sulfuric acid. The nitrogen determination was performed using the Kjeldahl method with the modifications described by Tedesco and coworkers[15]. The digestion temperature was increased by the addition of sodium sulfate. Phosphorus was analyzed by flame spectrometry using ammonium molybdate and 1-amino-2-naphthol-4-sulphonic acid. The analysis of Cu and S was done by atomic absorption spectometry, after digestion of the samples with nitric and perchloric acids. The analysis for Ni was performed by flame photometry after extraction with 0.1 N HCl. The content of organic carbon was done following a method described by Tedesco and coworkers[15].

RESULTS AND DICUSSION

The results obtained for N, P, Cu, organic C, S and Ni are summarized in Table I. The content of organic carbon exhibited almost uniform values and varied from 30 per cent by weight (sample 2B) and 37 per cent by weight (sample 6B).

TABLE I. CHEMICAL ANALYSIS OF SOIL SAMPLES FOR N, P, Cu, S, Ni AND ORGANIC CARBON.

SAMPLES	1B	2B	3B	4B	5B	6B	7B	8B
Nitrogen %	2.0	1.7	1.7	1.7	1.4	1.7	2.0	1.7
Phosphorus %	0.13	0.13	0.08	0.08	0.06	0.07	0.07	0.07
Copper-ppm	17	20	15	17	12	12	9	20
Organic C %	31	30	32	33	35	37	35	32
Sulfur %	0.39	0.33	0.28	0.25	0.24	0.29	0.44	0.37
Nickel-ppm	15	16	11	8	8	3	4	9

TABLE II. SOME GEOCHEMICAL CHARACTERISTICS OF SOIL SAMPLES.

SAMPLES	1A	2A	3A	4A	5A	6A	7A	8A
Hygroscopic humidity %	8.5	7.9	8.2	8.6	8.4	8.6	7.6	8.2
Ash in humid base %	28.2	35.8	33.5	23.6	18.2	16.4	20.4	29.5
Heat content cal/g	3100	2900	2800	3400	3400	3900	3600	3100
Silicon-ppm	5890	1320	7060	1650	1160	1840	2020	3800
Sodium-ppm	425	190	316	227	96	140	136	166
Iron-ppm	13960	10570	6320	4450	2620	2750	2190	3080
Aluminium-ppm	19475	17560	11240	9900	7860	6450	6120	11160
Calcium-ppm	7210	4530	4660	3720	3220	3510	3940	3500
Magnesium-ppm	2080	1500	1310	1010	830	890	1140	910
Potassium-ppm	680	490	370	234	206	213	270	274
Ca/Mg-ppm	3.46	3.02	3.55	3.68	3.89	3.94	3.45	3.84

% by weight;
Samples collected in Terra de Areia on May 3, 1995.

Nitrogen varied from 1.4 per cent by weight (sample 3B) to 2 per cent by weight (samples 1B and 7B). Sulfur ranged from 0.24 per cent (sample 5B) to 0.44 per cent (sample 7B). The values obtained for phosphorus varied from 0.24 per cent to 0.44 per cent by weight. The results for copper ranged from 9 ppm (sample 7B) to 20 ppm (samples 2B and 8B) while those of Ni exhibited minimum and maximum values between 3 ppm (sample 5B) and 16 ppm (sample 2B).

Table II summarizies the experimental results obtained for K, Mg, Ca, Al, Fe, Na and Si. It also contains results obtained for the heat content, ashes in dry and wet base and hygroscopic humidity.

The elements Na, K, Mg and Ca showed values that ranged from (96, 206, 830 and 3220 ppm - sample 5A) to (425, 680, 2080 and 7210 ppm - sample 1A), respctively. Aluminium and iron exhibited the lowest values in sample 7B (6540 and 2750 ppm) and the highest values in sample 1A (19475 ppm and 13960 ppm), respectively. Silicon ranged from a minimum of 1160 ppm (sample 5A) to 7060 ppm (sample 3A). The heat content ranged from 2800 cal/g (sample 3A) to 3900 cal/g (sample 6A). The ash content in dry and wet base varied from 17.9 and 16.4 per cent by weight (sample 6A) to 38.9 and 35.8 per cent (sample 2A), respectively. The hygroscopic humidity ranged from 7.2 per cent to 8.6 per cent in samples 4A and 7A, respectively.

The soil studied was formed in an environmental with high humidity by the accumulation of organic matter of plant origin. There were also external contributions both mineral (sedimentary transport) and of plant origin (invasion by plants of the depression while it was being filled). The mineral matter may also were come from decomposition of plants that contain on the average about 6 per cent of the same (closed geochemical cycle). It may have also come in solution or suspension in the feeding waters or by eolic means.

The carbon present in these soils increases linearily with the degree of humification of the filling material. This is due to the formation of more complex carbon compounds that in turn depend on the mature of vegetation that gave rise to the soil. In the case of slow deposition, lignin and cellulose play an important role in this process. When this organic matter containing C, H, N, O and S is subject to combustion it liberates heat, that is alled the heat content. The heat content determination and the amount of organic carbon present allows the classification as peat or peat sediment.

The experimental results obtained indicate a good correlation between heat content and ash content determined. Figure 5 illustrates this correlation. As exppeeted, samples with the highest heat content exhibited the lowest ash content.

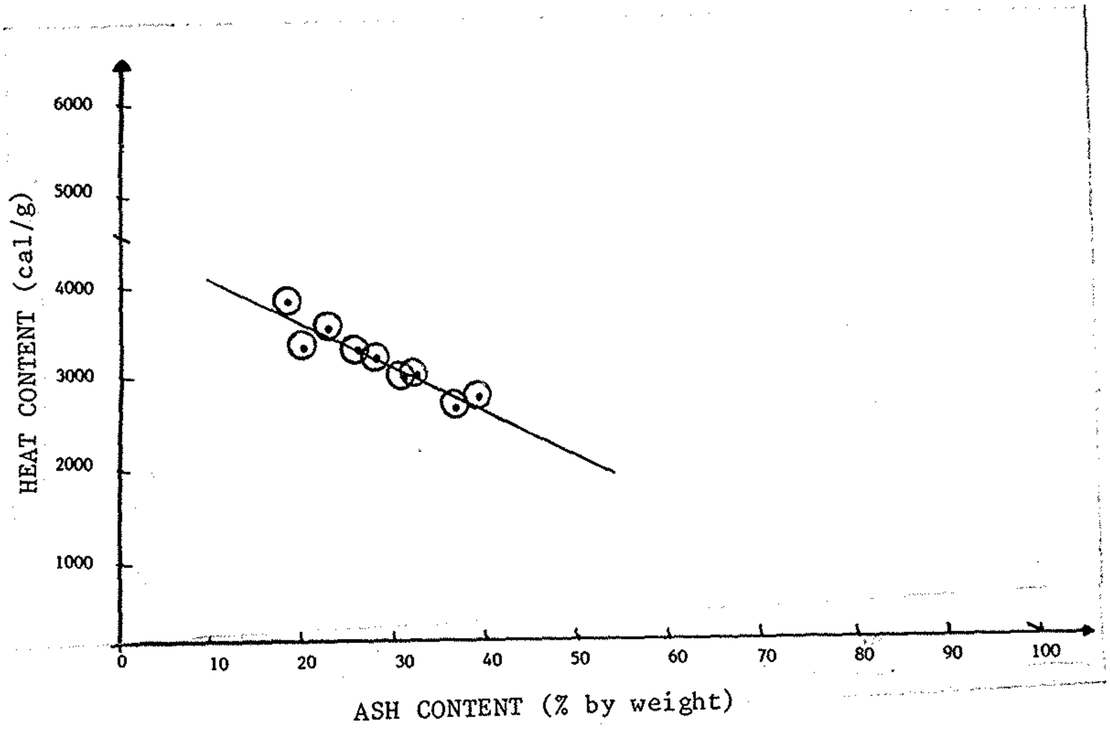

FIGURE 5. CORRELATION BETWEEN HEAT AND ASH CONTENT FOR THE SOIL SAMPLES STUDIED.

The humidity determined at 105°C is compatible with this type of soil and exhibits higher values in the samples collected near creeks, and lower values elsewhere, indicating a major compactation of the material and increase in clay minerals at these sites.

The sulfur content was rather low. This is explained by the lack of direct marine influence and the plant organic origin of the sulfur.

The nitrogen present in these soil is essentially the result of decomposition of plant proteins.

Phosphorus is mainly present as phosphate and it is related to fertilizing properties.

Typical turfland studies suggest concentrations of N, S and P of the order of 1, 0.25 and 0.1 per cent, respectively[1]. Nitrogen may reach up to 4.5 per cent and S may vary from 0.5 to 5 per cent, depending on the degree of humification. The soil under consideration comes from a wetland and it has a low degree of humification.

The Cu content of soils from Southern Brazil varies from 0.1 to 5 ppm[15]. The higher contents found in the present study are due to soil retention. The Cu distribution clearly follows the pattern of drainage of the site of study.

Nickel is not essential for the growth of plants, is therefore not bioaccumulated and its concentration usually follows that of ashes[1]. The present study did not allow as to conclude wheter Ni is due to pollution or simply the entry of mineral matter.

Sodium and potassium are highly soluble monovalent cations, are easily last by soils because they from weak organic complexes and are usually present in low concentrations. The bioaccumulation of K is due to plant degradations while Na, that is not essential for plants, is usually transported by water. The low concentration of both ions in wetlands is most likely a direct consequence of drainage.

Magnesium and calcium are divalent cations that form unstable organic complexes; Ca appears to be essential to plant growth and the usual Ca/Mg ratio[1] for fresh waters is 3:1 and both are retained. The ratios measured in this study agree with this observation and ranged from 3.02 to 3.84. All the ions mentionmed so far including Mg^{++}, Ca^{++}, Na^{+}, Ni^{+++} and Cu^{++} reflect drainage conditions of the site.

The soils that we studied are acid soils (pH of percolation waters is about 3.5) and this factor is very important in the consideration of ionic species of Al and Fe. Ions such Al^{+++} and Fe^{+++} are toxic to plants and become soluble below pH 5. On the other hand Fe^{++} is essential for plants but is oxidizes to Fe^{+++} in marshy environments. In this case, its availability to plants depends essentially on the pH and the oxidation conditions of soils[1]. The presence of iron leads to the acidification of waters and is inversely proportional to water flow, following the same pattern as of the percentage of saturation with oxygen. Both Al and Fe are retained by these soils.

In other type of soils Si in the form of SiO_2 varies normally from 240000 to 330000 ppm. In our case, where we dealt with an organic soil the Si content was much lower (1160 to 7060 ppm). The Si content is directly related to ash content and inversely related to heat content.

The present study allows as to reach the following conclusions:

- the choice of the site of study was adequate and permited a good geochemical characterization of the sediments;
- there was good agreement between our results and results reported in the literature for similar soils;
- the site studied cannot be classified as a turfland based on the heat content, ash content and organic carbon. Usually the requirements for such classification are a heat content above 3500 cal/g, organic carbon above 60 per cent and ash content lower than 35 per cent by weight;

- the results of the elements analyzed although giving slightly different values from those reported in the literature, follow the same pattern and permit us to suggest that the site will become a turfland in the geological future;

- the pattern of water drainage is in agreement with the metal concentration determined at the different sites of the wetland;

- the study was significant in terms of hydrological and environmental aspects and provides knowledge for a better preservation of this important coastal ecosystem.

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