CORRELATION ANALYZE BETWEEN PH VALUES, NITRATE CONCENTRATION, CONDUCTIVITY ELECTRIC, PRECIPITATION VOLUME AND WIND DIRECTION IN CUIABÁ CITY RAIN, MATO GROSSO STATE, BRAZIL.

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Abstract

The research about rains acidity has been done principally in industrialized regions, where observe an efect more visible of human interference result in environment that can return on society. This job intends to analyse the values of rains acidities in Cuiabá/MT - Brazil, observing correlation between pH values, nitrate concentration, conductivity electric, precipitation volume and wind direction in this city that possess a dry and wet tropical climate, with two well defined seasons, been a wet and a dry season alternate. Has been installed a rain collection equipment in Jardim Imperial area, East region of Cuiabá (LW 56º 01' 33'' e LS 15º 36' 40'') in open area, free of obstacle that could contaminate the samples. Initially of each rain the rain collection equipment was open, avoiding contamination by drought deposition and the pH value and conductivity electric were measure just after rain end. Right away the sample was store correctly and frozen to later chemical analysis. Were collected 43 samples between 21/09/2004 (rain initiate) to 20/01/2005. Have been measured data of pH, electric conductivity, nitrate, wind direction, precipitation volume an days without rain. The pH values varied between 4,25 to 6,45, been 25,6% were lower than 5,0, 44,2% between 5,0 to 5,59, 20,9% between 5,60 to 6,00, and 9,3% higher than 6,01. During all months the pH average (VWM) was lower 5,6 varying between 5,04 to 5,29. The rain volume varied between 0,1 to 62,0 mm, the total rain volume in this period was 586,5 mm.

Predominant wind direction was WSW that has occurred in 12 events. To analyze these data, was codify wind direction using two values, where number zero was utilized when the wind direction origin could not influence results, and one when the wind direction origin could influence data results, like wind direction origin from downtown or industrial district. Nitrate concentration varied between lower 0,02 to 0,38 mg/l, and was possible to verify that a decreases monthly nitrate concentration, in October was 0,15 mg/l and in January was 0,03 mg/l. Days numbers without rain also were analyzed, so during these days the atmosphere can concentrate more pollutants, and have varied between 0 and 8 days without rain. Have been utilized 34 samples to calculate the correlation matrix, where was possible to find a negative correlation of -0,97068 between pH values and nitrate values, a significant inverse correlation. In the others correlations were not found good results. The nonexistence of researches about rains acidity in Cuiabá and the nonexistence of others data about rain composition do not allow major conclusions about these results.

Key-words: acid rain, Cuiabá-MT, burning, human interference

1. INTRODUCTION

The research about rains acidity has been made mainly in industrialized regions, where observe a

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more visible effect of the result of the human interference on the environment that can finish returning for the proper society. The acid rain formation is a serious consequence that the atmospheric pollution provokes in the environment, and can be produced of natural sources (volcanic smoke emission, for example) or artificial (emissions proceeding from industries or automobiles, for example). In a world-wide scale it is observed that the studies about rains acidity are boarded in regional or global way (Castro & Tarifa, 1999), leading in account that the atmospheric circulation can dislocate the pollutant emissions in the atmosphere up to 2.000 km of its generating sources, while that in Brazil the studies are in a regional or local scale.

There is carbonic acid naturally in the atmosphere, that is acid weak, and natural pH rain is around 5,6 (Goldemberg and Villanueva, 2003), however studies had demonstrated that if it does not have to generalize this value, therefore already had been found in remote areas rains with acid values, indicating that naturally can have factors that diminish pH of rains. Like this is weighed to affirm that there is acid rain occurrence when pH found to possess a lower value that 5 (Galloway et al., 1982). In regions as the United States and Sweden, the values of pH of rains if find between the values of 4 and 5 (Goldemberg and Villanueva, 2003). Half of the German forests was destroyed by the action of acid rains and the acidification of Sweden lakes (Goldemberg and Villanueva, 2003) and Norway lakes (Drew, 2002) - that destroyed part theirs aquatic life - had been provoked by the high acidity of pluvial waters.

The objective of this work was to follow the behavior of the acid value of rain in the region east of Cuiabá, Mato Grosso State – Brazil, as well as observing which factors they can influence in the concentrations of the analyzed elements and in the rain acidity. The nonexistence of a continuous monitoring about acid values of rains in Cuiabá, makes with that this type of study if becomes important.

2. STUDY AREA

Cuiabá - capital of the State of Mato Grosso - is a city with humid and dry tropical climate (Ayoade, 1998), whose municipal headquarters that also is the geodesic center of the South America if find in the coordinates 15°35'56 "LS and 56°06'01" LW. It possess two well distinct stations, being a wet and dry alternately. During the dry season (May to September) some damages in the vegetal covering are provoked, and because of city localization in the tropical area, possess only some cold days in the winter, which had the arrival of deriving cold fronts of the southern regions, and possess next annual average rainfall of 1.500 mm.

The process of urban expansion resulted in the conurbation process between Cuiabá city and Várzea Grande city that together possess about 178 thousand vehicles circulating (Detran-TM, 2003) and about 700 thousand inhabitants (IBGE, 2000). There is a great number of urban burning focus, mainly during dry season, what can increase gases concentration and suspended solid material in air (IAP, 2000), and consequently to affect the health of its population. The present work was carried through in a residence of the Jardim Imperial district (LW 56º 01 ' 33"and LS 15º 36' 40") – East Cuiabá area, figures 1 - that possesss in its entorno a great area of vegetal covering that comes suffering constant process from deforestation for the construction of new habitacionais sets. There is about one kilometer a drinks industry. To the north (n) of the collection point it is the region of the Centro Político Administrativo - CPA (densely populated), to the South (S) the next region to the Industrial District, the East (E) we have a green area and the other districts like Osmar Cabral and Tijucal, and the West (W) the Porto district and part of downtown city (that if it also extends the northwest - NW).
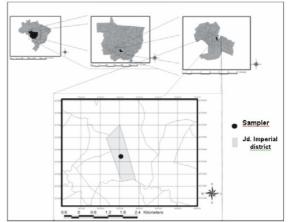

Figure 1. Study Area Map

3. METHODOLOGY

Studies on acid rain

Some studies have been carried through in different points in the world, as published for Morales et al. (1998) in Venezuela, Kulshrestha et al. (1996) about New Déli-India, which has observed that cement industry emissions and the ground particles (respectively) can neutralize the acidity of rains. Tuncel and Ungör (1996) had observed similar effect in the Ankara region, in Turkey. In England, the studies of Beverland et al. (1998) in the city of Berkshire observed the influence of the wind direction in the rains acidification, mainly for carrying the pollutants from different points of England and Europe.

In Brazil we can observe studies in metropolitans areas of São Paulo (Castro e Tarifa, 1999), Rio De Janeiro (De Mello, 2001), and in the Rio Grande city, in the South (Mirlean et al., 2000), where it is evidenced predominance of acid average values in rains of these places. In the forests areas, like the studies in the region of Lago Calado - Amazon (Willians et al., 1997), and in the Parque Nacional de Itatiaia, in the SE region (De Mello and Almeida, 2004) evidenced lightly acid average values, what it indicates the wind influence like transporting agent of pollutants.

Materials and Methods

Was installed a manual collector of samples in the Jardim Imperial district (LW 56º 01 ' 33"and LS 15º 36' 40") in opened area, the 1 meter on floor, free of obstacles that could contaminate the collected samples, being only opened in the beginning of each rain to prevent the contamination for dry deposition (Castro & Tarifa, 1999). The samples had been collected between 09/21/2004 until day 01/20/2005, had been monitored rains of first 4 months of the wet season in Cuiabá city.

The equipment was constituted of a polypropylene funnel with diameter of 27 cm, connected for a inert tube to a polypropylene bottle with capacity for 5,6 liters, forbidden with inert silica. The system was previously washed with deionizer water, before each use preventing contamination.

After each event (rain), a portable pH-meter (WTW model 330i/SET) was realized immediate measurement of sample pH, (pH-meter was calibrated previously to each measurement) and of the electric conductivity (Tecnopon model

mCA – 150), also calibrated before the measurements. After the measurements, samples was correctly conditioned in a polyethylene bottle, identified and frozen for posterior chemical analysis. Each samples had been submitted to quantified nitrate using procedures of the Standard Methods (American Public Health Association, 1985), through spectrophotometer UV (CELM, model E-225). The wind direction data had been obtained from an automatic climatologic station (Wheater Link) installed in the central region of Cuiabá. The correlation analysis was made using Minitab software version 13.2.

4. RESULTS AND DISCUSSION

Values of pH of the collected samples

The samples had been collected between 21/09/2004 to 20/01/2005, a total of 43 samples, where the found values of pH had varied of 4,25 to 6,45, where that 25.6% are minor who 5,0, 44.2% between 5,0 and 5,59, 20.9% between 5,60 and 6,00, and 9.3% above of 6,01. The volumetric average value of pH of the 43 samples was of 5,19. The volume-weighted-mean (VWM) of pH had varied of 5,04 (minimum, registered in January) to 5,29 (maximum, registered in December). It was observed that the monthly averages of pH (figure 2) increase gradually of October to December, when verifies the VWM of 5,29. This results indicates that October rains in (therefore the volume of precipitation in September was lower than 1 mm of rain) help to clean the atmosphere of the pollutant gases (even so suffers a fast fall in October), implying in the gradual reduction of rain acidity and an increase of pH average value. It is not possible to explain the value of the pH volumetric average in January.
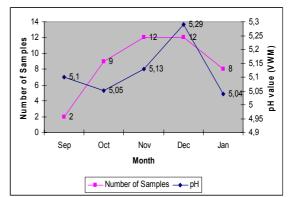

Figure 2 – Relation between pH value (VWM) and number of samples monthly

Wind Direction and its influence in rain pH

The wind direction predominant in the beginning of events was WSW with 12 events, indicating that 27.91% of rains in this period had this wind direction in its initial. In sequence the direction of predominant wind was W with 7 registered events. When compared with the VWM of pH, it was observed that the lesser gotten volumetric average value was when the direction of the wind in the beginning of rain was direction NNE, with VWM pH of 4,99. As the lesser VWM of pH was W direction with value of 5,01, followed for SE direction with 5,03. The VWM highest had been found with NW and SW wind direction, both with value of 5,65, like figure 3. The W wind direction indicates that wind is from region of the Porto district and for central region of Cuiabá City and NNE wind direction indicates that the winds are deriving of areas densely populated next CPA district, or either, from places where has a hard movement of automobiles, and consequently, a bigger dispersion of pollutants.
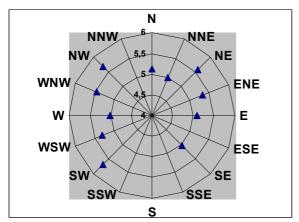

Figure 3 – Relation between pH value (VWM) and events wind direction.

Nitrate concentration

The nitrate (NO_3^-) concentration has been varied between 0,02 to 0,38 mg/l. Before each sequence of analysis in laboratory, spectrophotometer used was calibrated, generating a calibration curve that has been used in final calculations of samples nitrate concentration. In terms of VWM, the greater was registered in the month of October with average of 0,15 mg/l, and the minor was in the month of January with 0,03 mg/l. A gradual decreasing in VWM nitrate concentration was observed in the analyzed period, indicating that rains has cleaned gases that are dispersed in the atmosphere. Has been observed between October to December a gradual increase in

VWM of pH. However, in January month where was evidenced the lesser VWM nitrate concentration, also the value most acid of VWM pH was verified, this indicates that January acidity can be influenced by other parameter, that was not possible to identify in this moment. Figure 4 indicates the variation of the concentration of the monthly nitrate text in relation to the monthly average of pH.
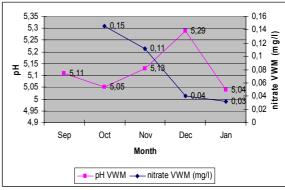

Figure 4 – Relation between values of pH (VWM) and nitrate VWM (mg/l)

Relationship between electric conductivity, pH value and nitrate concentration.

The biggest value that has been measured of electric conductivity in an event was 30,7 µS/cm (during November) and the lesser was 3,84 µS/cm in January, and the VWM in this period was 8,33 µS/cm. Mirlean et al. (2000) in its studies in the region of River Grande-RS found values that had varied of 4 the 39 µS/cm, which indicates a variation of 2 to 20 mg/l of totals of dissolved Salk. The VWM monthly had varied between 14,91 µS/cm in November to 5,90 µS/cm in January. Flues et al. (2002) has obtained a VWM of 22,5 µS/cm, during a project in a northeast region of Paraná State

It was observed that in the December, dissolved salk had a characteristic less acid than the other months, what resulted in a VWM pH of 5,29, while that in the other months these characteristics was different (more acid), influencing pH values - as figure 5. When compared with the VWM nitrate, has been verified that the values are not directly proportional, but with an accented reduction of nitrate concentration, electric conductivity has been diminished, as figure 6.
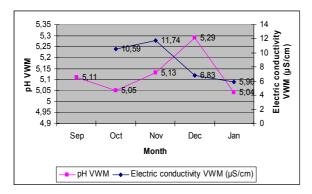
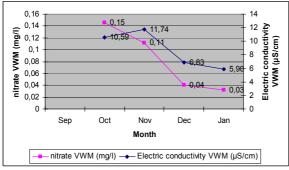Figure 5 – Relation between values of pH (VWM) and electric conductivity (µS/cm).

Figure 6 – Relation between VWM values of nitrate (mg/l) and electric conductivity (µS/cm).

Burning, days without rains and values of pH
The urban burning together with the industrial and automobilist pollution are the principals human influences to atmospheric pollution (IAP, 2000). Occurrences report of CIOSP (2005), between July/2004 and January/2005 had been registered 1970 occurrences of urban burning in Cuiabá and Várzea Grande City. In September was registered 709 occurrences, in October 151 occurrences and VWM pH did not present a good variation when compared September with October. With a great number urban burning, it is natural a bigger dispersion of pollutants in the atmosphere, however is necessary to know its characteristics, so can acidify or neutralize the acidity that exists in the atmosphere.

However, as this kind of association has not been very studied, it is difficult to affirm in this moment how urban burning can influence in rain acidity of, been important the continuity of this kind of research to analyze influences that can occur. When compare relationship between pH samples to number of previous days without rain, was not observed direct influences in the rain acidification. This indicates that same with

rain absence, there are a tendency of the dispersed pollutants to neutralize the atmospheric acidity, once that a great part of most acid values was found when had rained in previous day, or in the same day, as what it indicates figure 7.
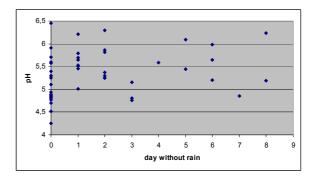

Figure 7 – Relation between samples pH with number of previous day without rain

Correlation Analyze
Observing matrix correlation below (table 1), verify that exist a significant negative correlation between pH and nitrate values of - 0,971, where how much bigger the nitrate concentration the pH value will be lesser (rain is more acid) and how much lesser nitrate concentration, higher will be pH value. Has been used 34 samples of the 43 collected, because was not possible to analyze all variables principally in function of collected volume.

Table 1 – Correlation Matrix between variables:

Variáveis	1	2	3	4	5	6	7
1	1,00000						
2	-0,97068	1,00000					
3	-0,02816	0,04964	1,00000				
4	-0,00844	0,02027	0,37801	1,00000			
5	-0,23200	0,20869	-0,45494	-0,18712	1,00000		
6	-0,06503	-0,00426	0,12827	-0,08057	-0,25126	1,00000	
7	0,04732	-0,03411	-0,05972	0,17690	0,19968	0,11746	1,00000

1- pH value; 2- nitrate concentration (mg/l); 3- electric conductivity (µS/cm); 4- rainwater temperature (°C); 5- precipitation volume (mm); 6- wind direction (codified); 7- number of previous day without rain.

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5. CONCLUSION

Acid rain is resulted principally of the human influences in the environment. In this study, data analyses had allowed to evidence the acid rain occurrence in the Cuiabá City, Mato Grosso State - Brazil, where 25.6% of 43 samples collected had presented pH value lower that 5,0 (Galloway et al., 1982). However, when the lower pH values of 5,6 are considered, it was verified that 69.8% of the samples had presented acid values lightly. The lowest pH value obtained was 4,25 and the highest was 6,45. When correlation analyze has been used between data of pH value, nitrate concentration, electric conductivity, rainwater temperature, precipitation volume, wind direction (codified) and numbers of days without rain, was evidenced significant inverse correlation of - 0,971 between pH values and nitrate concentration. The few sampling and the nonexistence of previous data makes it difficult a deep association of the measured data, including the fact that was not possible to analyze all the substances presents in rainwater (as calcium, ammonia, magnesium, potassium) and that could influence in the results. The inexistence of a research continuous of rain acidity in Cuiabá became important the sequence of the sample collections, because will be possible to compare if the variation acidity present in each year, therefore the society comes intervening each time more in the nature dynamics. The first effect can be observed with the occurrence of acid rains - even so lightly acid - but if make necessary to accomplish monitoring of the situation that can be affecting the health human being, and also the vegetation, rivers and soil.

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