# Effect of the application of slaughterhouse wastewater treated on stabilization ponds on soil and corn development

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## Abstract

The objective was to evaluate effect of application in different doses of wastewater from slaughterhouse in an Oxisoil and on corn development . The wastewater was collected after treatment in stabilization ponds. Doses of 150 $m^3$ $ha^{-1}$, 450 $m^3$ $ha^{-1}$, 900 $m^3$ $ha^{-1}$ and 1350 $m^3$ $ha^{-1}$ of wastewater were applied during the growing season of corn. It was used 12 columns of soil of 0.25 m in diameter and 0.65 m in height. The percolated material was analyzed at all doses and presented a reduction of the nitrogen parameters (Kjedhal) of 0.02 g $L^{-1}$ and phosphorus of 0.1 mg $L^{-1}$ in all treatments. At higher doses, 900 $m^3$ $ha^{-1}$, the potassium content was 12.08 mg $L^{-1}$ and calcium and magnesium increased by 40% and 173% on average, respectively. It was observed a sodium reduction of 92% and there was reduction of BOD and COD. The plants that received the doses 450 $m^3$ $ha^{-1}$, 900 $m^3$ $ha^{-1}$ and 1350 $m^3$ $ha^{-1}$ presented higher values of green matter, length of spike and number of leaves. The soil fertility has not undergone dramatic changes with respect to the parameters analyzed.

**Key words**: effluent, nutrient recycling, post-treatment, reuse, lysimeter.

## Introduction

The Northwest region of Paraná State is distinguished by the diversity of agro-industrial activities, such as the segment of animal treatment, especially poultry and cattle for milk and beef, starch, pudding and sugar and alcohol plants (REIDEL et al. 2004 , SILVA et al. 2004). According to Abrahão et al. (1999), the northwestern region of Paraná State presents a higher level of development than other regions, not only by increased participation in pasture areas and number of animals and farmers, but by the ability to support and the farm size. According to information from regional SEAB this region has 66 companies in the industry of cattle slaughterhouse located and operating with 740,000 animals per year, from animals slaughtered in the regional nuclei of Maringá, Paranavaí, and Umuarama. A major problem found in refrigerators cattle is suitable treatment and final destination of wastewater and served water, as a result of the slaughter and beef processingf, which has been concern for environmental agencies and society in general, which shows the polluter character. The effluents of these industries have high concentration of organic matter, detergents and sanitizers (CECCHINI, 2003), probably due to the operations of cleaning and sanitization. In spite of potentially polluting industry often, this does not receive the right attention of society, since they do not handle highly toxic chemicals substances, however, the surrounding society soon feel the presence of this industry. And this is especially noticed in the receiving bodies that has its balance affected (SILVEIRA, 1999). It is emphasized that the world market is increasingly demanding environmental issues, search for quality certification and, consequently, the environmental certification for the markets of developed countries, and it may restrict the future exports to those markets. (CECCHINI, 2003).

According to the technical data of Espinoza (1998), a large-sized company slaughters 1,200 cattle per day, producing on average 2,400 $m^3$ $day^{-1}$ of wastewater. In this way, the production of wastewater in the northwest of Paraná State, was around 1,480,000 $m^3$ in 2006. Before being prepared for the environment, the wastewater generated must be addressed through systems of three stabilization ponds that most of the times do not remove completely the excess of nutrients such as nitrogen and phosphorus, causing serious problems of eutrophication in water bodies (REIDEL et al., 2004). Therefore, the provision of wastewater after treatment in the system of receiver bodies can be either on the ground or in rivers close to the industry. However, the environmental legislation sets the maximum allowable number of parameters according to classes of rivers. Still, according to Reidel et al. (2004), at the end of the polishing pond, the third pond, the content of ammoniacal nitrogen in wastewater is situated around 200 mg $L^{-1}$.

The CONAMA Resolution n º 357 (2005) allows a wastewater to be released up to 20 mg $L^{-1}$, and is therefore still necessary to evaluate an adequately way of disposal the possible use of this organic effluent. The legislation allows the agroindustrial wastewater to be disposed in soil, since there is no contamination of water, whether underground or surface depending on the class of water bodies. As the waste generated at slaughterhouses are organic and have no toxic compounds, there is the possibility of disposal in soil as an alternative for recovery of nutrients, reducing the volume of waste to be treated, reducing costs and pollution of water bodies. Therefore, it is necessary to evaluate the effect of wastewater on soil and crops. In this context, this study aimed to evaluate the application of wastewater from slaughterhouse cattle after the third pond of the treatment system soil columns as to the effect: (i) the chemical attributes of sandy soil, (ii) in the effluent leachate, (iii) and the behavior of the corn crop.

## Material and methods

This study was conducted in the experimental area on the Arenito campus , Maringá State University (UEM), at Cidade Gaúcha - PR, geographically located at 23º 21' 30.01' latitude S, 52° 56'5,81" longitude W, and altitude of 345 m. The work was carried out from February to June of 2007, totaling 126 days.

### Columns of soil

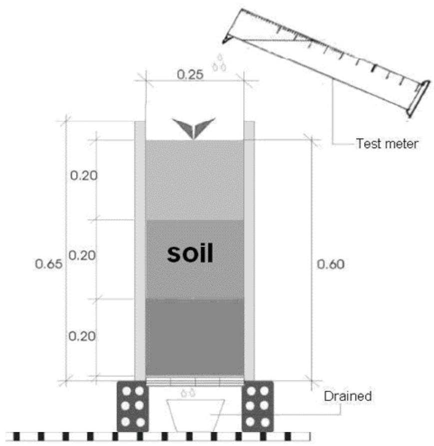
It was used 12 tubes of PVC (Figure 1) cross-section of 0.25 m in diameter (surface area of 0.049 $m^2$) per 0.65 m in height (total volume of 0.0319 $m^3$) filled with soil from 0,60 m. The soil columns were installed vertically to a height of 0.20 m above the ground spaced to 0.45 m between them. The tubes were scraped internally in order to promote slots in the wall to increase the soil adhesion to the tube wall. Three rings made of PVC glue were placed every 0.15 m depth to reduce thewastewater runoff effect on the tube wall used in this space (BARROS et al. 2003). A double layer of perforated plastic material was placed in the bottom of the tube, known as 50% sunlight allowing percolation of the effluent in the soil column.

### Soil

The columns were filled with Latossolo Vermelho Distrófico (Oxisoil) which was withdrawn of a single area, continuous and uniform, to the depth of 0.60 m. The soil was composed of 830 mg $kg^{-1}$ of sand 10 mg $kg^{-1}$ of silt and 160 mg $kg^{-1}$ of clay.

**Figure 1.** Local installation of the experiment: column of sandy soil: (a) photo of the columns of soil percolation with corn (40 days after sowing) in the oven and (b) the soil column in detail and layers of soil.

(a)




(b)

**Table 1.** Chemical characteristics of soils before the experiment

| Soil depth (m) | pH $H_2O$ | $Al^{3+}$ | $H^{+}+Al^{3+}$ | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+}$ | SB | CTC | P (mg dm$^{-3}$) | C (g dm $^{-3}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | cmol$_c$ dm$^{-3}$ | | | | | | |
| 0,00 - 0,20 | 6,4 | 0,0 | 2,19 | 1,20 | 0,34 | 0,20 | 1,74 | 3,93 | 10,5 | 3,52 |
| 0,20 - 0,40 | 6,2 | 0,0 | 2,19 | 1,28 | 0,37 | 0,17 | 1,82 | 4,01 | 4,7 | 3,91 |
| 0,40 – 0,60 | 6,6 | 0,0 | 2,03 | 1,10 | 0,38 | 0,08 | 1,56 | 3,59 | 3,0 | 3,13 |

Samples of soil horizons at depths of 0,00-0,20 m, 0.20-0.40 m 0.40-0.60 m were removed separately, dried in air for 60 hours and sieved at 2 mm in order to form air dried samples and were analyzed for chemical attributes (Table 1). The soil of each layer was placed in the lysimeter in the same sequential order of soil depths.

The elements Ca, Mg, K, Na and P were determined after nitric-perchloric acid digestion of the material, the Ca and Mg measured by atomic absorption spectroscopy, the K and Na by flame emission photometry and phosphorus by a colorimetric method. Nitrogen was determined by the Kjeldahl method.

## Wastewater

The water used in the experiment to supplement the plant water requirement was from artesian well water. The wastewater was collected at the exit of the third pond of stabilization in a medium-sized cattle slaughterhouse located in Cidade Gaúcha, PR, with a slaughter capacity of 300 head per day, which generated 600 m$^3$ of wastewater. The solid residue was separated from the liquid before the treatment system, in preliminary treatment, and followed for another destination. The pond received three types of wastewater: *(i)* the line of wastewater treatment of meat containing blood, called a Red Line that goes through boxes of fat for removal of aninals oils and greases going to the treatment system, *(ii)* wastewater generated in corrais before slaughter, called Green Line, whose destination were settling boxes for separation of solid residues (stomach contents, gut, paunch and animal manure) of the supernatant that are directed to production of other products and *(iii)* wastewater from the operations of cleaning and sanitation that add substances derived from detergents and sanitizers. The wastewater was then routed to a system of treatment of three ponds.

## Material leachate

The percolated wastewater and the wastewater applied to the soil columns were characterized during the experimental period for macronutrients (Ca, Mg, K, P, N and Na). Ca, Mg, K, Na and P were determined after nitric-perchloric acid digestion of the material, the N by the Kjeldahl method, Ca and Mg by atomic absorption spectroscopy of the K and Na by flame emission photometry and, P by colorimetry and sulfate ion ($SO_4^{2-}$) by turbidimetry of barium chloride. The analysis of COD (chemical oxygen demand) and BOD (Biochemical Oxygen Demand) followed methods described in APHA (1995).

## Treatments

The experiment consisted of four treatments with three replicates in a completely randomized design (CRD). Treatment one (T1) received the equivalent to 150 m$^3$ ha$^{-1}$ for vegetative cycle culture. This amount corresponded to the maximum suggested by the Environmental Institute of Paraná (IAP) and was applied in a single dose 12 days after sowing (DAS). Treatment two (T2) received the equivalent to 450 m$^3$ ha$^{-1}$ per year of wastewater, which was applied in three times at regular intervals of four days from the 12$^{th}$ day after sowing (DAS). Treatment three (T3) received the equivalent to 900 m$^3$ ha$^{-1}$ per year of wastewater, which was applied six times, from 12$^{th}$ DAS. Treatment four (T4) received the equivalent to 1350 m$^3$ ha$^{-1}$ per year of wastewater, which was applied nine times, from 12$^{th}$ DAS.

In Table 2 are shown the doses of slaughterhouse wastewater applied and their dates. Before and after planting, soil moisture was kept close to field capacity to avoid water deficit. The dose of 150 m$^3$ ha$^{-1}$ corresponded to the area of the soil column the amount of 750 mL.

## Conducting the experiment

In January 2007, three seeds of maize (*Zea mays* L.) variety BR 106 were sown in the soil column and in 10th DAS the thinning were done to establish only one plant per lysimeter. The surface of the soil column was covered with dry straw of corn and weed control was done by manual weeding. During the crop cycle there was a total rainfall accumulation of 411.2 mm. Figure 2 shows the frequency of precipitation. Adding the total precipitation accumulated, the additional and the doses of wastewater in each column was applied a total quantity of 1376.2 mm during a period of 126 days.

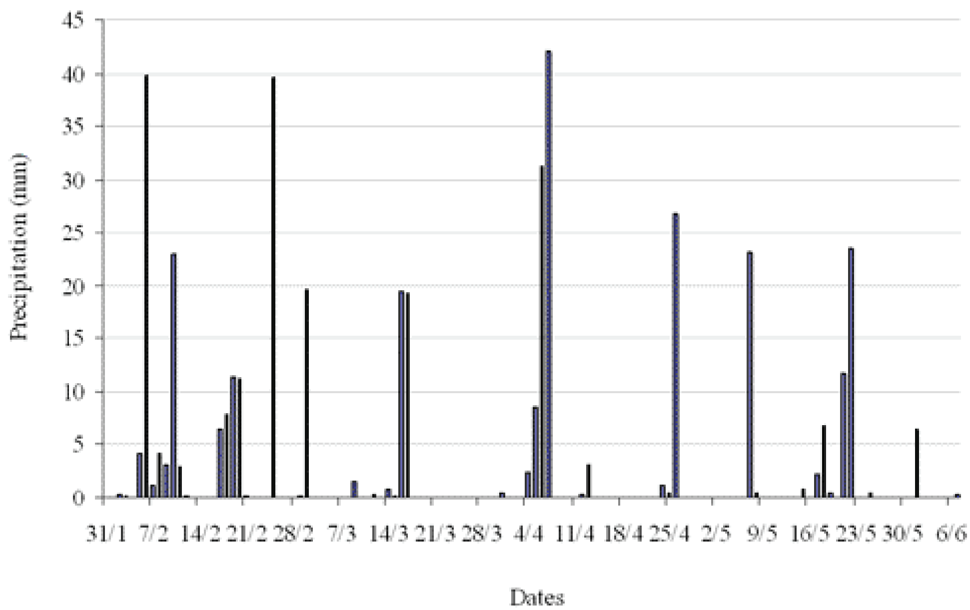
Samples of leachate were collected in 16th (16 / 2), 48th (20 / 3) and 82th (21 / 4) DAS in each of the treatments (T1, T2, T3 and T4) for analysis of macronutrients. These three samples were composed of wastewater percolated at different times of wastewater application and collection of leachate material: (1) since the 12th DAS (date of first application) until the 16th DAS (date of first collection), (2) sample percolated since the 40th DAS (the fifth day of application) until the 48th DAS (date of second collection corresponding to approximately one third of the total period of the growing season of corn), and (3) composite percolation sample corresponding to the period of 40th until the 48th

**Table 2.** Dates and Doses of wastewater applied per treatment.

| Date of application | DAS* | Applied dose ($m^3$ $ha^{-1}$) | | | |
|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 |
| 12/02 | 12 | 150 | 150 | 150 | 150 |
| 14/02 | 14 | - | 150 | 150 | 150 |
| 16/02 | 16 | - | 150 | 150 | 150 |
| 19/02 | 19 | - | - | 150 | 150 |
| 12/03 | 40 | - | - | 150 | 150 |
| 22/03 | 50 | - | - | 150 | 150 |
| 01/04 | 60 | - | - | - | 150 |
| 11/01 | 70 | - | - | - | 150 |
| 21/04 | 80 | - | - | - | 150 |
| Total | | 150 | 450 | 900 | 1350 |

** DAS: days after sowing.*

**Figure 2.** Frequency of precipitation in the experimental period.



DAS which was mixed with the sample collected in the 82nd on the last application of wastewater in the 80th DAS, as it can be seen in Table 2. In the collection of 48th and 82nd DAS a composite sample was analyzed on the content of macronutrients, DQO and DBO.

The collection was held to 126th days after sowing, following the procedures recommended by Freitas et al. (2004) and Tsumanuma et al. (2004) when the corn had physiological maturity of grain (at 126 DAS). The plants cutting was done manually at 5 cm soil.

The plant components: plant height, insertion spike height, stem diameter, length of spike, number of leaves per plant, dry matter, green matter were obtained from each treatment. The results were analyzed by analysis of variance and the averages were compared according to the Scott Knott test at 5% level of probability. After the corn harvest at 126 DAS, a composed sample of three replicates of each treatment of 0,00-0,20 m, 0.20-0.40 m 0.40-0.60 m soil depths of all treatments was done, to assess the effect of applications of different doses of wastewater.

## Results and discussions

### Evaluation of soil

The soil samples taken from the profiles showed no significant variation between the layers. Based on average results of chemical analysis of soil, Table 5, it can be mentioned that the acidity of the soil in all treatments, including the initial soil was due to $H^+$ ions, since it was not detected ion $Al^{3+}$. The analysis of the treatments showed that there was little variation observed for the mean and standard deviation values (6.07 ± 0,27). Still, it was observed that in the layer 40 to 60 cm there was greater variation, being 12% higher in the soil of T1 (with 150 $m^3\ ha^{-1}$) compared with the initial soil in the same layer. In the layer from 20 to 40 cm it was observed a lower variation of 4.8% in T3. These results indicate that applications of wastewater with these doses did not affect the soil pH (RODRIGUES, 2001). The application of wastewater even in higher doses did not promote increase in pH beyond the optimum range of pH 5.5 to 7.0 for most crops. Despite having leachate around 0.3 mg $L^{-1}$ of phosphorus in the treatments that received doses of 900 $m^3\ ha^{-1}$ and 1350 $m^3\ ha^{-1}$ (Table 4), the soil had a minimal amount of that nutrient of 2.8 mg $dm^{-3}$. In the surface layer of soil from 0 to 20 cm, it is observed that there was a reduction of initial soil phosphorus to the soil of all treatments in the same layer, reaching average reduction percentage of 62%. Percentage of phosphorus reduction can be observed in the plots irrigated by wastewater from slaughterhouse investigated by Rodrigues (2001) up to 23%. The phosphorus was the element that presented higher variation in relation to other elements measured in the soils of the four treatments, with an average of 3.78 mg $dm^{-3}$, the maximum being between treatments of 6.5 mg $dm^{-3}$ (T4: 20 to 40 cm) and a minimum of 2.8 mg $dm^{-3}$ (T3: 40 – 60). The highest average of each treatment was obtained in profiles of T4 with 4.9 mg $dm^{-3}$ and the lowest 3.3 mg $dm^{-3}$ in T3. This can be attributed to two likely factors: either the sampling of the leachate did not really presented the quantity of nutrients lost or the corn of each treatment absorbed the element quickly.

In relation to the pH, is observed values from 5.8 to 6.4, considered below the neutral (pH 7.0). This factor may have facilitated the absorption of phosphorus by plants, as the wastewater was rich in this nutrient showing 28.72 mg $L^{-1}$ of phosphorus in soluble form. Moreover, the sandy soil used in this experiment adsorbs smaller amount of phosphorus in the form of phosphate than a clay soil. There is the layer from 40 to 60 cm a lower concentration of P compared with the upper layers in almost all treatments, due to the phenomenon of P fixation occurred in the first 50 centimeters of soil.

In the surface layer of soil from 0 to 20 cm, it is observed that there was a reduction of K in 40% of the initial soil to the soil of T1 and T2, in 30% and 25% in treatments T3 and T4, respectively. In the layer from 20 to 40 cm, there was a percentage reduction of approximately 55% in all treatments. However the deeper layer (40 - 60 cm) results presented that there was no significant variations of potassium in the soil in all treatments. Rodrigues (2001) found that addition of the slaughterhouse wastewater was reduced by 18% of K in post-treatment system of the sewage treatment. The base saturation did not have changed drastically because the supply of minerals was continuing as the need of the plant, which caused no change in the value of V%.

In order to be considered fertile, a soil have to maintain the level of base saturation in the range of 40% to 65% on the soil surface and at least 40% by the 60 cm depth of soil, which should be done using of limestone and gypsum. It also keeps the soil balanced with P, N and K, and contain micronutrients (DEMATTÊ, 2005).

## Evaluation of wastewater

Table 4 presents the chemical characterization of wastewater collected at the end of the third stabilization pond. It can be observed that the N had 300 mg $L^{-1}$, the wastewater was composed of residues of blood that have a high protein value. This value is below the ones cited by CETESB (2006) for waste collected from the end of slaughterhouses, which should provide about 30 g $L^{-1}$ of N, COD of 400 g $L^{-1}$ and BOD of approximately 200 g $L^{-1}$. Observe that the values of BOD and COD found in the wastewater also differ from the values described by CETESB (2006). However, the value of 300 mg $L^{-1}$ is above the limit recommended by CONAMA Resolution n º 357 (2005) that provides 20 mg $L^{-1}$ for releasing of effluents into water bodies.

## Evaluation of effluent leachate

Table 5 presents the chemical composition of the percolated effluent of each treatment in the three samples taken.

It can be observed that the concentration of nitrogen in wastewater percolated at 16th DAS decreased from 328.2 mg $L^{-1}$ to 0.6 mg $L^{-1}$ in all treatments. In collecting 48th and the period of 48th – 82nd DAS was recorded an increase on the previous collection. This could have occurred due to the higher layers applied due to the application

**Table 3.** Chemical analysis of soil, for layers from 0 to 20 cm, 20 to 40 cm and 40 to 60 cm, before and after wastewater application.

| Samples | Profile cm | pH $H_2O$ | $Al^{3+}$ (cmol dm$^{-3}$) | $H^{+}$+$Al^{3+}$ | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+}$ | SB | CTC | V % | P mg dm$^{-3}$ | C g dm$^{-3}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Soil | 0-20 | 6,4 | 0,0 | 2,19 | 1,20 | 0,34 | 0,20 | 1,74 | 3,93 | 44,27 | 10,5 | 3,52 |
| | 20-40 | 6,2 | 0,0 | 2,19 | 1,28 | 0,37 | 0,17 | 1,82 | 4,01 | 45,39 | 4,7 | 3,91 |
| | 40-60 | 6,6 | 0,0 | 2,03 | 1,10 | 0,38 | 0,08 | 1,56 | 3,59 | 43,45 | 3,0 | 3,13 |
| 150 $m^3$ $ha^{-1}$ | 0-20 | 6,0 | 0,0 | 2,19 | 1,11 | 0,38 | 0,12 | 1,61 | 3,80 | 42,37 | 4,7 | 5,42 |
| | 20-40 | 6,0 | 0,0 | 2,03 | 1,13 | 0,37 | 0,08 | 1,58 | 3,61 | 43,77 | 3,3 | 4,26 |
| | 40-60 | 5,8 | 0,0 | 2,19 | 1,26 | 0,42 | 0,07 | 1,75 | 3,94 | 44,42 | 3,3 | 3,49 |
| 450 $m^3$ $ha^{-1}$ | 0-20 | 6,1 | 0,0 | 2,03 | 1,03 | 0,35 | 0,12 | 1,50 | 3,53 | 42,49 | 3,3 | 3,87 |
| | 20-40 | 6,0 | 0,0 | 2,03 | 1,06 | 0,37 | 0,09 | 1,52 | 3,55 | 42,82 | 3,6 | 3,87 |
| | 40-60 | 6,0 | 0,0 | 1,88 | 1,08 | 0,36 | 0,07 | 1,51 | 3,39 | 44,54 | 3,2 | 5,04 |
| 900 $m^3$ $ha^{-1}$ | 0-20 | 5,8 | 0,0 | 2,03 | 1,03 | 0,32 | 0,14 | 1,49 | 3,52 | 42,33 | 3,9 | 4,26 |
| | 20-40 | 5,9 | 0,0 | 2,03 | 1,12 | 0,38 | 0,07 | 1,57 | 3,60 | 43,61 | 3,1 | 4,26 |
| | 40-60 | 6,0 | 0,0 | 1,88 | 1,21 | 0,39 | 0,06 | 1,66 | 3,54 | 46,89 | 2,8 | 3,10 |
| 1350 $m^3$ $ha^{-1}$ | 0-20 | 6,1 | 0,0 | 2,03 | 1,07 | 0,32 | 0,15 | 1,54 | 3,57 | 43,14 | 4,1 | 3,49 |
| | 20-40 | 6,0 | 0,0 | 2,03 | 1,17 | 0,39 | 0,08 | 1,64 | 3,67 | 44,69 | 6,5 | 3,87 |
| | 40-60 | 6,1 | 0,,0 | 2,03 | 1,17 | 0,43 | 0,06 | 1,66 | 3,69 | 44,99 | 3,5 | 3,87 |

**Table 4.** Characteristics of wastewater from slaughterhouse cattle collected at the exit of the third pond of treatment.

| Variables | Values (mg $L^{-1}$) |
|---|---|
| Ca | 15,29 |
| Mg | 5,12 |
| K | 66,62 |
| Na | 88,27 |
| P | 28,72 |
| N | 328,20 |
| DBO | 641,00 |
| DQO | 789,00 |

**Table 5.** Characteristics of wastewater percolated collected in 16th, 48th and 82nd DAS

| DAS | Treatment ($m^3 ha^{-1}$) | Ca | Mg | K | Na | $SO_4^{2-}$ | P | N | DQO | DBO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (mg L-1) | | | | | | | | |
| 16o | 150 | 35,5 | 16,3 | 17,4 | 3,3 | 0,5 | 0,1 | 0,6 | n.a. | n.a. |
| | 450 | 24,5 | 12,5 | 14,4 | 1,4 | 0,3 | 0,1 | 0,6 | n.a. | n.a. |
| | 900 | 21,2 | 13,9 | 15,6 | 2,0 | 0,3 | n.d. | 0,6 | n.a. | n.a. |
| | 1350 | 30,6 | 13,2 | 14,4 | 1,5 | 0,3 | 0,1 | 0,6 | n.a. | n.a. |
| 48o | 900 | 4,62 | 2,74 | 6,09 | 3,69 | n.a. | 0,56 | 2,76 | n.a. | n.a. |
| | 1350 | 13,06 | 6,12 | 12,12 | 6,79 | n.a. | 0,05 | 5,52 | n.a. | n.a. |
| 48o – 82o | 900 | 0,88 | 1,22 | 12,20 | 6,83 | n.a. | 0,30 | 5,52 | 61,00 | 18,00 |
| | 1350 | 11,03 | 5,68 | 12,08 | 3,67 | n.a. | 0,30 | 2,76 | 18,00 | 15,00 |

*n.a.: not analysed; n.d.: not detected;*

of successive doses in quantities exceeding the retention capacity of soil (FREITAS et al., 2004). The concentrations of nitrogen in wastewater percolated into the soil to a depth of 0.60 m along the cycle of the corn crop, regardless of the treatments studied, did not exceed the standards recommended by CONAMA resolution 357 (2005) of 0.02 g $L^{-1}$ (about the ammonia nitrogen), indicating no risk of contamination of groundwater. Due to the low mobility of phosphorus in the soil, the concentration of this nutrient in the leachate was 0.1 mg $L^{-1}$ at 16th DAS. In the collections made at 48th and in the 48th – 82nd period there was an increase of concentration due to higher doses applied and the capacity retention of phosphorus in the soil.

The potassium concentration over the three sampling collections, for T4 had reduced the wastewater applied from 66.62 mg $L^{-1}$ to 14.4 mg $L^{-1}$, 12.12 mg $L^{-1}$ and 12.08 mg $L^{-1}$ respectively for 16th, 48th and 48th – 82nd DAS. To the concentration of calcium, it was observed that the soil in all treatments, percolated in the 16th DAS increased by over 40%. Probably, this element was released from the solid phase, as the wastewater was poor in this element. In subsequent samples, a decrease of calcium concentration in the leachate of T3 in the 48th DAS of 70% and in the collection made in the period 40th - 82nd DAS of 94%. In T4, the reductions were 15% and 27% in 48th and 40th - 82nd DAS, respectively. The same behavior observed for the calcium ion was observed for the magnesium ion that has increased the concentration in the 16th DAS of 173% on average for all treatments, as data presented in Table 4. Then, the leachate removal was observed only in T3 from 46% in the 48th DAS (with 2.74 mg $L^{-1}$) and 76% in samples collected in the period from 48th to 82nd DAS (with 1.22 mg $L^{-1}$ ).

Considering the results for these elements (Ca, Mg, N, P and K) it can be inferred that the wastewater applied to longer time of distribution is a source of nutrients for the development of maize, since the amount of applied elements did not increase concentrations determined in soil profiles in all treatments.

Regarding the content of Na in the leachate, it can be observed that there was a decreased in percentage of at least 92% (with 6.83 mg $L^{-1}$ on T3 made in the collection of 48th-82nd DAS) and a maximum of 98% (with 1,4 mg $L^{-1}$ on the 16th DAS of T2).

Considering the values of BOD and COD of wastewater *in nature* and of the leachate in soil columns, it was found that there was almost total reduction of BOD and COD in the effluent leachate.. This reduction, according to SILVA et al. (2004), is probably directly related to retention of all the organic matter retained in the first centimeters of the columns of soil. Thus, the leachate material has less organic matter and requires a much smaller quantity of oxygen, either by chemical and / or organic via.

## Components of corn crop production

The results for the plant parameters evaluated are presented in Table 6. The average plant height, spike diameter, stem diameter and dry matter did not differ statistically at 5% level by the Scott Knott test. While for the variables, number of leaves, length of spike and green matter only T1 was not different from the others. The T2 presented significant difference to the others in relation to the insertion high of the spike (Table 6) affected by different levels of fertilization by wastewater. T1, T3 and T4 did not differ, but the T2 differed from the others, reaching heights of insertion of the spike of 73.03 cm. Regarding plant height, it was obtained an average value of 129.1 cm to 148.1 cm. According to research done by EMBRAPA (2003), the variety BR 106 used had a great potential to present a height of 240.0 cm. Based on analysis of the obtained results of the parameter number of leaves and length of the spike the treatments T2, T3 and T4 were higher than the treatment of lower dose of wastewater (T1), therefore due to the concentrations of nutrients are lower, according to data presented in Table 6.

Mendonça et al. (1999) studied levels of nitrogen fertilization in maize found maximum values of 15.63 cm in length of spike and 145 cm for spike height of insertion of the spike.

## Conclusions

According to the doses of slaughterhouse wastewater collected at the end of the third lagoon of the treatment system applied to soil columns, it can be conclude that:

(i) there was no change in the chemical attributes of sandy soil measured from the soil at the beginning of the experiment. The results indicated that irrigation with treated wastewater from slaughterhouse may be used for agricultural production without soil exhaustion in the short term;

(ii) after passage through the soil column, there was reduction in all parameters measured in the leachate effluent, therefore, in this case, the soil acted as a post-treatment filter of the wastewater from slaughterhouse cattle;

(iii) no effects were observed on the components of production of maize.

**Table 6.** Components of production of the corn crop.

| Treatment | Variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **AL (cm)** | **AIE (cm)** | **CE (cm)** | **DE (cm)** | **NF (un)** | **DC (cm)** | **MS (g)** | **MV (g)** |
| T1 - 150 $m^3 ha^{-1}$ | 129,2a | 50,83a | 6,55ª | 23,63a | 11,00a | 2,363a | 46,34a | 47,2 a |
| T2 - 450 $m^3 ha^{-1}$ | 148,1a | 73,03b | 9,94 b | 28,25a | 13,00b | 2,825a | 55,23a | 104,8b |
| T3 - 900 $m^3 ha^{-1}$ | 129,1a | 53,00a | 9,28 b | 29,93a | 13,33b | 2,993a | 59,05a | 105,9b |
| T4 -1350 $m^3 ha^{-1}$ | 128,6a | 45,63a | 10,15b | 34,93a | 14,00b | 3,493a | 58,05a | 143,5b |
| CV (%) | 17,41 | 15,24 | 17,67 | 19,91 | 5,00 | 19,91 | 20,41 | 29,9 |

*AL – plant height; AIE – height of insertion of the spike; CE – length of spike; DE – diameter of the spike; NF – number of leaves; DC – diameter of the stem; MS – dry matter; MV – green matter;*

## References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