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Possibility of using chip burning ashes and chicken slaughterhouse effluent sludge as soil concealer

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Abstract—*The objective of this study was to analyze the composition of the ashes generated in the boiler of a slaughterhouse that slaughter ninety thousand chickens per day and to evaluate the possibility of using the ashes as a conditioner and soil fertilizer. The research was conducted in the largest slaughterhouse and birds of Espírito Santo. The ashes were collected directly from the boiler after cooling, a one hundred and fifty gram sample was separated and sent to a soil chemical analysis laboratory. The following parameters were evaluated: hydrogen potential (pH), phosphorus (P), potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), aluminum (Al), cation exchange capacity at pH 7 (T), base saturation index (V), effective cation exchange capacity (t), exchangeable base sum (SB), aluminum saturation index (m), nitrogen (n) and total or potential acidity (H + Al). The results of the ash characterization showed the presence of beneficial nutrients such as potassium, phosphorus, magnesium and calcium, but the calcium content was considered low, medium magnesium and good for cultivation, high potassium and phosphorus. Regarding the possibility of using natural ash as an aid in soil improvement, the results showed that the concentrations are in disagreement with the recommended. The pH value obtained was considered high 9.78, above the recommended for use as a conditioner in soil fertilization, which would be a more neutral pH around 5.5 to 6.0. However, most Brazilian agricultural soils have medium to high acidity, which results in low crop yield. Thus, the use of ashes can be considered in specific cases of known very acidic soils. However, annual soil analyzes should be performed to monitor the evolution of the behavior of these nutrients, as well as the pH in the areas used for deposition of this material. These reviews are a good suggestion for future long-term research.*
Keywords— ***chip burning ashes, chicken slaughter, soil concealer.***

I. INTRODUCTION

Brazilian poultry has shown high growth rates. Its main asset, chicken, has conquered the most demanding markets. The country has become the third world producer and leader in exports (SINDIAVIPAR, 2015). It is an area in constant and rapid development in the agrifood industry and generates significant amounts of waste, which characterizes a constant challenge regarding its recycling (MIERZWA-HERSZTEK et al., 2016). At the end of the process of processing the production chain are the modernized slaughterhouses that guarantee the quality of the product, from the arrival of birds in the place where they will be slaughtered, until the dispatch of the product (CPT, 2014).

It is an area in constant and rapid development in the agrifood industry and generates significant amounts of waste (BEUX, 2005; GARCIA, 2016). Blood is considered the most problematic and complex component, which hinders efficient effluent treatment as a way to reduce environmental impacts (MORÉS, 2006).

An effective form of wastewater treatment is coagulation followed by flotation. Flotation is a complex physicochemical process, where countless variables affect its efficiency, the size of the bubbles and the size of the particles having the greatest impact on the process (SENA, 2005). This process increases the efficiency of removing organic matter, oils and greases from water by adding coagulants and coagulation aids, followed by the adhesion of these particles to the float bubbles; However, this form of treatment generates a large amount of residual sludge to be treated for its proper destination (VIRMOND, 2007).

One of the ways to reduce the volume of sludge generated is heat treatment, and one option for heat treatment of sludge is pyrolysis, which is defined as the thermal decomposition of oxygen-limited organic matter, which forms useful by-products as : the liquid called bio-oil and the solid called biochar (VIEIRA NETO, 2012). According to Meneghini and Proinelli (2015) the burning of primary sludge under favorable conditions can contribute significantly to the energy production through combustion in wood boiler. For this reason, its main use is as fuel in furnaces (BARBIERI et al., 2014).

The aim of this study was to analyze the composition of the ashes generated in the furnace of a slaughterhouse that slaughtered 100,000 chickens a day and to evaluate the possibility of using them as soil fertilizer. The refrigerator is located in the south of the state of Espirito Santo. These ashes are generated from the burning of pine and eucalyptus chips and the primary refrigeration sludge.

II. REVIEW

Brazilian poultry presented high growth rates, where chicken conquered the most demanding markets (GARCIA, 2016). Poultry activity in Brazil is more concentrated in the South and Southeast, which together account for 75% of the country's total production.

The broiler production chain in Brazil has competitive advantages due to the fast production cycle, the fact that it has the possibility of a vertical and technological organizational structure, besides the low cost protein, attracts consumers from different social classes (RECK; SCHULTZ , 2016). The incorporation of new technologies enables the improvement of production and control systems, the reduction of energy and raw material costs, the diversification of the energy matrix and the variety of industrialized products offered (ESPÍNDOLA, 2012). However, this increase in production needs increasingly efficient refrigerators with high effluent production and large sludge generation.

In slaughterhouse sludge, high levels of microbiological contaminants are found (MÉNDEZ-CONTRERAS et al., 2009). Cammarota (2011) reports that primary effluent treatment aims to remove existing solids in the effluent with the aid of additives such as coagulants and coagulation adjuvants, followed by particle adhesion in the rising air bubbles in the flotation tanks. Flotation processes as primary treatment are commonly used in effluents that have a high load of suspended oils and greases such as slaughterhouses and meat processing industries, and aim to increase the efficiency of organic matter removal from water (SENA). , 2005).

The floated sludge is basically composed of carbon, oxygen and nitrogen, due to its process of being exclusively organic. However, some substances from the physicochemical treatment process contribute to its formation, such as coagulants and coagulation aids (FERREIRA, 2016). During the effluent treatment process, an organic or inorganic coagulant such as aluminum polychloride, ferric chloride or aluminum sulfate is added (MAGNAN, 2010).

According to Vieira Neto (2012), an option for the thermal treatment of sludge is pyrolysis, which is the thermal decomposition of organic matter with limited oxygen supply, where a useful by-product such as the biochar solid is formed. This process can be an option for treatment and utilization of poultry slaughter sludge (GARCIA, 2016). The ash content is related to the nutrient content present in the material. This material component is determined after its complete combustion, when all organic elements are volatilized (ENDERS et al., 2012). Biochar is a carbon-rich product obtained when a biomass or organic material undergoes thermal decomposition under limited oxygen supply (LEHMANN; JOSEPH, 2009).

Vegetable ash is a residue from burning wood and sludge that, depending on its origin, may have high levels of Potassium, Phosphorus, Calcium and Magnesium, and may be used as a nutritional supplement, depending on the balance presented by the soil and requirements of culture (ZHANG; YAMASAK; NANZYO, 2002).

Ash recycling reduces the need for commercial fertilizers, contributing to reduced soil acidification and increasing the supply of calcium and potassium to plants (SOFIATTI et al., 2007). Bonfim-Silva et al. (2015a) argue that using plant ash for fertilizer purposes contributes to plant development. However, Mukone et al. (2013) warn that the potential and effectiveness of using biochar as a source of some nutrients varies according to the chemical characteristics of the material that composed it; In its composition, ash usually contains high concentrations of calcium and potassium.

Vegetable ash typically has high pH, nutrient concentration such as phosphorus, potassium, calcium and magnesium and essential micronutrients for plant growth (ZHANG; YAMASAHI; NANZYO, 2002). Ferreira, Fageira and Didonet (2012), also observed the positive effects of vegetable ash in Cerrado soils, the results pointed to the significant improvement of some chemical properties such as pH, potassium and magnesium. Bonfim-Silva et al. (2015a) found a linear increase in soil pH, and the values increased from 6.3 to 7.2 by the application of 20 g dm^{-3} (approximately 40 t ha) of eucalyptus wood ash in a Cerrado Oxisol, collected in Rondonópolis Mato Grosso.

Bonfim-Silva et al. (2011a) observed, studying plant ash as a soil corrective and fertilizer for marandu grass, that the use of this residue may contribute to soil fertility, especially in tropical and low fertility soils. Thus, there is a substantial reduction in weight, essentially associated with losses in gaseous forms of water, carbon and nitrogen, with insignificant amounts remaining in the gray (OBERNBERGER; BRUNNER; BÄRNTHALER, 2006). The application of vegetal ash in Dystrophic Red Latosol provided significant increases in Crotalaria juncea cultures, increasing the shoot dry matter production by 89.38% (BONFIM-SILVA et al., 2011b). Wang and Wang (2019) state that biochar, as it is also called biochar, has been used for soil remediation and improvement as well as carbon sequestration. Pereira (2019) reports that biochar is rich in stable carbon, being one of the alternatives for reducing long-term greenhouse gas emissions, as well as improving the chemical, physical and biological characteristics of soils.

Lopes et al. (2005) stated that research carried out, including experiments in greenhouse and field conditions, has shown that the recycling of nutrients contained in vegetable ash through the farm has great practicality, but it is necessary to know the chemical composition. of this residue and the appropriate dose for each culture, avoiding nutritional toxicity or deficiency due to the excess of some nutrients such as Calcium and Magnesium that compete significantly for the active absorption sites.). Biochar is considered a material with an effective bioadsorption. (CHEN et al., 2018). Under controlled and field conditions, the recycling of nutrients contained in vegetable ash through the farm presents great practicality; However, they also warned that it was necessary to know the chemical composition of this residue and the appropriate dose for each culture, avoiding nutritional deficiency or toxicity due to the excess of some nutrients (OSAKI; DAROLT, 1991). Bonfim-Silva et al. (2015), verified positive response of cotton plants cultivar FMX 910 regarding the application of biomass ash to a Red Latosol. For PIVA et al. (2014), ashes may serve as an alternative to easily accessible fertilization, usually with reduced cost and a high sustainable contribution to the environment. Chenlu Fu et al. (2020) state that the porous structure of ash supports and hosts fine particles of organic matter and is thus a good soil conditioner.

Regarding toxic metals, several studies have shown the efficacy of biochar in the immobilization of cadmium, copper, lead, arsenic and zinc, as well as reduction in bioavailability and phytotoxicity of these metals to plants (PARK et al., 2011; BEESLEY; MARMIROLI , 2011). Liu, Liu and Zhang (2014) showed that although biochar increased the concentration of toxic metals in the soil as a result of the higher adsorption of these metals, the presence of biochar made the metals unavailable to plants. In this sense, the sustainable use of biochar must consider the characterization of the material of its composition and the place of application, such as the physicochemical properties of the soil and climate (VERHEIJEN; MONTANARELLA; BASTOS, 2012).

Meneghini and Proinelli (2015) warn that the refrigerated waste generated by the effluent treatment, from the slaughter process of chicken, pork and meat industrialization, have high costs of disposal to landfills. Seiffert (2000) states that according to the legislation this material must have an appropriate disposal or final disposal that does not pollute the environment, making it impossible to dispose directly in landfills without proper treatment. This has promoted research aimed at a smaller generation, or better, use of this material.

However, not everything is an advantage when using Biochar. According to Mukherjee and Lal, (2014), experiments that evaluate biochar as a soil conditioner present scarcity in the amount of field-level data for plant growth responses, soil quality and environmental impact. The authors further comment that biochar responses as a soil conditioner are based on a short time and laboratory or greenhouse studies, and are sometimes contradictory. Wang and Wang (2019) claim that biochar has a broad prospect of application in environmental remediation, but its long-term effect on soil microbiota should be further investigated.

Adding biochar could also promote rapid loss of forest humus and soil carbon in some ecosystems during the first decades (WARDLE; NILSSON; ZACKRISSON, 2008). In addition to having the presence of PAH (polycyclic aromatic hydrocarbons) in biochar, which may be a limiting factor for its use as a soil conditioner (DE GRYZE et al., 2010). In the process of producing biochar, pyrolysis also provides the formation of bio-oils, which may have small levels (PAH) (SOHI et al., 2009). The potential presence of heavy metals and other hazardous elements in biocarbons

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may endanger their use as a soil conditioner (BRACMORT, 2010; DE GRAYZE et al., 2010). However, Kavita et al. (2018) state that biochar due to its high surface area, porosity and functional groups provide excellent adsorption capacity of heavy metals and organic pollutants.

III. METHODOLOGY

The research was carried out in the largest poultry slaughterhouse and slaughterhouse in Espírito Santo and at the São Camilo University Center, Espírito Santo. The refrigerator is located in Aracuí, municipality of Castelo, under the coordinates 24k 2707703 / UTM 7715353.44.

According to the administration of the refrigerator in question, it generates 950 direct jobs and 350 indirect jobs, without taking into account the employees who work in feed mills and in the chick production sector. The company has a farinheira, which reuses production residues such as nails, beaks, viscera, blood, feathers and oil; These materials benefit and become raw material for the production of feed. The refrigerator has an installed slaughtering capacity of 100,000 birds per day with a daily consumption of two million four hundred thousand liters of water a day, generating a large amount of effluent.

The ashes were collected directly from the boiler after cooling, it was placed in a plastic bag with a capacity of ten liters, the bag was sealed so that the sample did not lose its moisture and taken to the Engineering Laboratory of the University Center São Camilo - ES. . Figure 1 shows the ashes leaving the boiler.

Fig.1: Ashes leaving the boiler.
Source: Elaborated and Adapted by the author.

After collecting the material directly in the refrigerator furnace; In the Engineering Laboratory of the University Center São Camilo - ES, the residue was dried in an oven at 121 ° C for two hours, revolving the sample at 30-minute intervals (ANDREOLI; SPERLING; FERNANDES, 2014). After this a sample of 150 grams was separated and sent to the Raphael M. Bloise Soil Chemical Analysis Laboratory of the Federal University of Espírito Santo (UFES), Alegre campus - Center for Agricultural Sciences. At this site, the following parameters were evaluated: hydrogen potential (pH), phosphorus (P), potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), aluminum (Al), cation exchange capacity a pH 7 (T), base saturation index (V), effective cation exchange capacity (t), exchangeable base sum (SB), aluminum saturation index (m), nitrogen (n) and total or potential acidity (H + Al).

The equipment and procedures used to quantify the parameters were, for each: 1- pH (by soil-water relation); 2- phosphorus (by Mehlich-1 extractor and determination by colorimetry); 3- potassium and sodium (by Mehlich-1 extractor and flame spectrophotometry); 4- calcium and magnesium (based on KCl 1 mol L-1 extractor and determination by atomic absorption spectrometry); 5- aluminum (1 mol L-1 KCl extractor and titration determination); 6- total acidity (by 0.5 mol L-1 calcium acetate extractor); 7- nitrogen (by the kjeldahl method by sulfuric digestion and steam distillation). The Organic Matter parameter was not analyzed due to equipment problems during the analysis period.

After obtaining the parameter values, the results were analyzed, according to current legislation, for possible applications for cultivable soils. Each parameter was specifically studied according to its concentrations or values required for use as fertilizer or soil correction, as well as consultations in the literature considered, as presented in Tables 1 and 2.

For sum of exchangeable bases (SB) and nitrogen (N), classification tables were not adopted and, therefore, their values were framed according to research in the literature considered as in Cruz, Pereira and Figueiredo (2017), Embrapa (2010) and Grant (2001).

In the Engineering Laboratory of the University Center São Camilo - ES, analyzes were made to know the pH of the ashes and compare with the result obtained by the Raphael M. Bloise laboratory of the Federal University of Alegre. Nine analyzes were performed to obtain the pH of the boiler ashes, through the methodology of maceration, sieving, dissolution of two grams of ashes in 50 ml of distilled water for 24 hours and use of pH meter.

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Chart 1 - Patterns or nutritional levels for each parameter, except SB, n and H + Al.

Element/Unit	Description	Low	Medium	High
pH (acidity)	Hydrogenionic potencial	< 5,0	5,0 – 1,0	> 6,0
Al (cmolc/dm³)	Alumínum	< 0,5	0,5 – 1,0	> 1,0
Ca (cmolc/dm³)	Calcium	< 1,6	1,6 – **3**,0	> 3,0
Mg (cmolc/dm³)	Magnsium	< 0,4	0,4 – 1,0	> 1,0
K	Potassium	< 30	30 – **60**	> 60
CTC (cmolc/dm³)	Effective cation exchange capacity	< 2,0	2,0 – 4,0	> 4,0
CTC a pH 7,0 (cmolc/dm³)	Cation exchange capacity at pH7	< 5,0	0,5 – **15**	> 15
M (%)	Aluminum saturation index	< 30,0	30,0– 50,0	> 50,0
V (%)	Base saturation index	< 50,0	50 – 70	> 70,0

Source: Procafé Foundation (2015).
Note: Adapted by the author.

Table 2 - Nutritional standards or levels for exchangeable base sum (H + Al).

Element / Unit	Description	Low	Medium	High
H + Al (cmolc/dm³)	Total or potential acidity	< 4,0	4,0 – 2,0	> 2,0

Source: Procafé Foundation (2015).
Note: Adapted by the author.

IV. RESULTS AND DISCUSSIONS

The pH value obtained was considered high 9.78 (Table 1), which is above what is recommended for use as a conditioner in soil fertilization, which would be a more neutral pH around 5.5 to 6.0 (Table 1). 3) as stated by EMBRAPA (2015). However, Veloso et al. (1992) stated that most Brazilian agricultural soils present medium to high acidity, which results in low crop yields. Thus the use of ashes could be considered in specific cases of very acidic soils.

The results of the ash characterization showed the presence of beneficial nutrients such as potassium, phosphorus, magnesium and calcium, but the calcium content was considered low, medium magnesium and good for cultivation, high potassium and phosphorus. Regarding the possibility of using natural ash as an aid in soil improvement, the results showed that the concentrations are in disagreement with the recommendations by EMBRAPA (2015).

Table 1 - Physical and chemical characterization of natural ash.

Result of Physicochemical Characterization of Natural Ash						
PH	**Phosphor (P)**	**Potassium (K)**	**Sodium (Na)**	**Calcium (Ca)**	**Magnesium (Mg)**	**Aluminum (Al)**
9,76	759,46 mg dm-³	779,00 mg dm-³	109,00 mg dm-3	0,61 Cmolc dm- ³	0,52 Cmolc dm- ³	0,0 Cmolc dm-³
H + Al	**Sum of bases exchangeable (SB)**	**Capacity and exchange effective cationic (t)**	**Capacity and exchange cationic at pH 7 (T)**	**Saturation index in bases (V)**	**Saturation index aluminum (m**	**Organic Material g / Kg**
0,0 Cmolc dm-³	3,60 Cmolc dm-³	3,60 Cmolc dm-³	3,60 Cmolc dm-³	100,00	0,0	0,0

Source: CCAE-UFES Soil Laboratory "Raphael M. Bloise". Center for Agricultural Sciences (UFES, 2019).
Note: Adapted by the Author.

Table 2 below was used to interpret the results regarding the acidity levels regarding the possibility of using the material.

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Table 2 - Interpretation classes for active soil acidity (pH).

Chemical classification						
Very high acidity	**High acidity**	**Medium acidity**	**Weak acidity**	**Neutral**	**Weak alkalinity**	**High alkalinity**
< 4,5	4,5 -5,0	5,1 – 6,0	6,1 – 6,9	7,0	7,1 – 7,8	> 7,8

Agronomic classification				
Very low	Low	Good	High	Very high
< 4,5	4,5 – 5,4	5,5 – 6,0	6,1 – 7,0	>7,0

Source: Ribeiro, Guimaraes and Alvarez (1999).

Note: Adapted by the author.

The results obtained in the analyzes at the Engineering Laboratory of the University Center São Camilo - ES regarding the pH of the ashes were compatible with the results obtained by the Raphael M. Bloise laboratory of the Federal University of Alegre. Table 3 shows the result of the nine analyzes performed using the pH meter.

Table 3 - Found pH values of the ashes.

Date	Temp. Water analyze pH	pH initial water	pH of water with ash after 24 hours
28/06/2019	25º	6,37	9,78
28/06/2019	25º	6,35	9,78
28/06/2019	25º	6,36	9,77
04/07/2019	25º	6,36	9,78
04/07/2019	25º	6,35	9,78
04/07/2019	25º	6,36	9,76
08/07/2019	25º	6,36	9,77
08/07/2019	25º	6,36	9,78
08/07/2019	25º	6,36	9,78

Source: Elaborated and Adapted by the author.

After all analyzes, an approximate average pH value for the ashes of 9.78 was obtained, obtained directly from the boiler, which Riberio; Guimarães and Alvarez (1999) and EMBRAPA (2015) classify as high alkalinity, as shown in Table 2. Figure 2 below shows one of the samples being tested at pH meter.

Fig.2 - Ash pH result.

Source: Elaborated and Adapted by the author.

Second Riberio; Guimarães and Alvarez (1999) an alkalinity above 7.8 should be considered high and therefore caution should be exercised regarding actions regarding the use and disposal of materials with pH similar to these values (Table 3). However, Silva (2003) states that pH should not be considered as a limiting factor regarding the use of materials in relation to their increase in soils and composting, since self-regulation results from microbial activities in the composting process and that the pH is higher. favorable for most microbial activities in composting activities is 6.0 to 7.5 for bacteria and between 5.5 and 8 for fungi. Santos (2007) working with organic waste composting products also states that the optimum value for pH is between 5 and 8.

Ash from vegetable residues presents high pH values, corroborating the results of this work, besides being good soil conditioners, increasing the yield of several crops and reducing fertilizer costs (ZHANG; YAMASAHI; NANZYO, 2002; LAIRD et al. , 2009).

The refrigerator has an area of 11 hectares in pasture areas in addition to environmental restoration areas. Soil analyzes of the pasture areas in question, which were carried out during the formulation of their fertigation project, found a pH of 4.9 considered high acidity according to Riberio; Guimarães and Alvarez (1999) and Embrapa (2011). Therefore, the addition of ash from the boiler could be considered as a factor of pH improvement of these areas and consequently of better soil conditioning.

The company also has 38 hectares of environmental restoration areas in a secondary stage of regeneration, considered as capoeirões, these areas have a naturally low pH soil, in soil analysis made in these areas the average pH found was 3.9 and thus considered as soils with very high acidity. This result is in agreement with that found by authors such as Rodrigues et al. (2010) who found soils with a pH average of 3.85 very high acidity, these results were obtained in areas of capoeirões. Miranda, Canellas and Nascimento (2007) obtained similar results by analyzing areas of Atlantic Forest fragments in secondary stage.

These two areas, the restoration and the pasture, could be used for the deposition of these ashes, thus helping to correct the pH of these remarkably acid soils. According to Ribeiro et al. (2015), ashes of plant origin have reasonable amounts of macro and micronutrients, as well as acidity corrective characteristics, thus having potential for their use in fertilization and correction of soil acidity. This would reduce annual spending by $ 24,000 a year to send ashes to the landfill.

V. FINAL COMMENTS

The ash characterization presented concentrations of some beneficial nutrients, but there are concentrations of other non-favorable factors such as pH, which obtained a result of 9.78, considered high above the ideal, since the ideal pH for most cultures, between 5.5 and 7.5.

Regarding the possibility of using ashes in nature as an aid in soil improvement, the results pointed to the presence of favorable nutrients such as potassium, phosphorus, magnesium and calcium, but the calcium content was considered low, medium magnesium, good for cultivation and high potassium and phosphorus. Therefore, it is suggested that long-term research be carried out regarding the evolution of soil dynamics behavior regarding the components present in the ashes as well as the soil biota responsible for nutrient cycling. The company has pasture areas and environmental recovery areas, which has 38 hectares of planted forest, currently in the secondary stage; plots to follow the evolution of ash in the soil could be set up in these areas and monitored.

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