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PRESENTATION AND EDITORIAL COMMENTS

Sustainable alternatives that promote economic circularity through the waste utilization is a strategic challenge for agricultural, livestock and agro-industrial systems to remain competitive and to generate new business models. The Brazilian Society of Agricultural and Agro-industrial Waste Management (Sbera) is the result of reflection, pioneering spirit and citizen commitment of professionals who intend to contribute to the evolution of the environmental condition of two large complexes of extreme social, economic and cultural importance for Brazilian agriculture and the agro-industrial sector. Found in 2008, Sbera promotes the International Symposium on Agricultural and Agro-industrial Waste Management (SIGERA) with the objective of fostering scientific debate and presenting technological alternatives to waste.

The VIII SIGERA, held at Universidade de Caxias do Sul/Brazil from 6 to 10 November 2021, was addressed the debate the “Science as basis for development”, to promote reflection and critical thinking about human evolution and the impacts of waste management. The VIII edition of symposium athered 415 subscriptions, including 303 paper authors and 112 attendant, including academic professors, researchers, undergraduate and graduate students from several Brazilian universities and research centers, as well as specialist professionals from the Argentina, Chile, Spain and USA. This This book of abstracts presents 89 scientific technical works selected for presentation during the symposium, divided into the following topics:

- Technologies for waste transformation, reuse and disposal
- Use of waste as fertilizer
- Environmental impacts to the air, soil, water and plant system
- Waste to energy
- Cases

The Scientific Committee hopes that the information present in this book of abstracts will be of value for future advances in the sustainability of food production.

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CASES

REUSE OF VEGETABLE FRYING OIL FOR BIODIESEL PRODUCTION: A PARTNERSHIP BETWEEN THE UNIVERSITY OF VASSOURAS AND THE CITY HALL OF VASSOURAS

Victor Fabiano Carneiro De Azevedo*, Danilo Alves Pereira, Denis Uiliam Candido Do Carmo, Dhyan Luca Tavares De Carvalho, Erick Barbosa Waack, Nicole Aparecida Martins Klimko Fraguas, Cristiane Pereira

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Oils and fats are triacylglycerides, a hydrophobic substance, i.e. insoluble in water belonging to the chemical class of lipids, and can be of animal or vegetable origin. The difference between oils and fats lies in their physical appearance. And with the significant increase of the population in cities, promoting the exacerbated consumption of food, including cooking oil, there is an inadequate disposal of this waste, which when in contact with soil and water, causes an environmental problem of great proportions. We can consider that it is necessary to establish a selective collection structure to prevent this substance from causing greater damage to the environment. Law 12.305, which deals with the National Solid Waste Policy, establishes guidelines for the proper disposal of waste. However, to date, this law does not include the collection of waste oil. For this reason, a Bill (PLS) was created in the Senate that aims to include the disposal of cooking oil. The Municipality of Vassouras, located in the Central South Fluminense Region of the State of Rio de Janeiro, has a consolidated program for waste collection, regulated by Municipal Law 2,881 of 2017, which defines the guidelines for selective collection and its execution. In order to promote environmental education among the population, a partnership was established between the Municipality of Vassouras, through the Municipal Department of Environment, Agriculture and Rural Development, and the University of Vassouras. The oil collected by the selective collection truck passes through the neighborhoods on specific days and is destined to the Laboratory of Unitary Operations and Bioprocesses, at Univassouras, where there is a semi pilot Bioprocess plant with 4 reactors. The biodiesel process begins with the characterization of the raw material, where the analysis and determination of impurities will be carried out. Then, it will go through the process of treating the oil and residual fat. Once this process is finished, a transesterification reaction will occur, adding methanol and a catalyst, in this case, sodium hydroxide, in the reactor, in which it will be stirred and heated resulting in biodiesel as a product and glycerin as a by-product. The biodiesel produced is treated and, once it becomes suitable, it can be incorporated into the fuel, following the regulations of the National Petroleum Agency, which allows only 12% addition to the selective collection truck. On the other hand, glycerin will be reused for the production of soaps and bioplastic, all of which will be developed by students and teachers of the Chemical Engineering course. In partnership with the Municipality of Vassouras, the joint commitment to sustainability and the valorization of environmentally responsible practices stands out. This initiative aims to reduce the environmental impact caused by improper disposal of cooking oil, reflecting the city's commitment to preserving the environment and the search for sustainable solutions in line with the 2030 Agenda and the SDGs.

HOW THE TYPE OF DAIRY PRODUCTION SYSTEM AFFECTS THE NUTRIENT BALANCE FROM AN ENVIRONMENTAL AND ECONOMIC PERSPECTIVE

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The knowledge of nutrient flow in dairy farms has to be explored to find optimized strategies for efficient nutrient conversion to milk. This study aims to improve the understanding of variances in nitrogen and phosphorus balance and efficiency indicators between dairy farm systems. This is the first study applying nutrient balance approach at a farm level to a tropical region in a developing country and considering three different production systems. This study analyzed 67 dairy cattle farms located in the watershed Lajeado Tacongava in the Northeast region of Rio Grande do Sul State, Southern Brazil. Selected dairy farms represented three production systems: confined (3 farms); semi-confined (7 farms); pasture-based (57 farms). Input–output nutrient balances were calculated at the farm gate level for nitrogen and phosphorus over a year. Inputs are feed and fertilizer and outputs are milk and animals. Inputs and outputs differ among different farm systems, and they are the main factors affecting nutrient budgets. The main nitrogen and phosphorus input on the all farms resulted from the feed. The average total N and P surplus on pasture-based farms were 4,899.7 and 693 kg year-1, respectively. In semi-confined systems were 9,276.2 and 1,178.1 kg year-1 and in confined systems were 22,806.1 and 2,239 kg year-1. When considering the monetary value of the total N surplus, the averages were US$ 2.615, 4.950.7, and 12.171.7 for pasture-based, semi-confined and confined systems respectively. Monetary values of P surplus were US$ 346.4, 588.8, and 1,119 for pasture-based, semi-confined and confined. The productive aspects that most determined the values of N and P surplus to 67 farms were the total number of lactating cows and the farm area. Results indicate that surplus can partially replace chemical nitrogen fertilizer, except in the confined system, and fully replace phosphorus fertilizer. Confined farms presented values to use surplus as fertilizer greater than the crop demand. For the other production systems, it happens only for phosphorus. Large variability between dairy farms of the same production system and between different production systems was observed. It reflects the inherent productive, economic, and environmental conditions of each farm and system.

APPLICATION OF NATURAL IRON OXIDES/HYDROXIDES FOR HYDROGEN SULFIDE REMOVAL IN SWINE MANURE BIODIGESTERS

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One of the challenges of using biogas as an energy source is the need of hydrogen sulfide (H2S) removal. In the case of biogas plants that carry out the biodigestion of organic substrates from the agroindustry, the chemical adsorption of dissolved sulfide in the liquid phase of biodigesters using iron salts stands out as a promising alternative. However, the high cost of chemical products is still a barrier to its widespread use in Brazil. Consequently, studies demonstrating the effectiveness of more affordable alternative sources of iron, such as clays or iron ore, are relevant.

Therefore, this work aims to present a case study of the application of Iron-Ox® Bio, a product commercialized by Óxido de Ferro Rio Acima, for the removal of H2S from biogas generated in a swine manure biodigester operated at 29-day HRT and a substrate flow of 85 m^3/d. The plant produces approximately 900Nm^3/d of biogas and has 500kW of installed power.

The study lasted 60 days and was divided into two stages. For the former, the amount of product necessary to obtain a 40% H2S removal efficiency was predicted, and for the latter, an attempt to reach a final efficiency of 65% was carried out. The amount of product was calculated from the operating parameters provided by the partner company, i.e., 25kg/d in the first phase with a surplus of 25kg/d in the first 7 days, 50kg/d in total. As of the 36th day (beginning of the second stage), the dose was maintained at 50 kg/d. The product was applied into the waste inlet box located near the substrate entry point in the biodigester.

Due to the longer reaction time of Fe2+ with H2S, the reduction in H2S concentrations is usually only noticed approximately 10 days after starting to apply the product. A reduction in the concentration of H2S was observed after the 8th day of application of the product, with an efficiency of 40% being reached from the 22nd day of monitoring. Increasing the dosage from the 36th day of the test provided the desired increase in removal efficiency, with efficiencies of 64% removal being achieved even 7 days after the last application of the product (53rd day). It is noteworthy that in order to reach an efficiency of 100% of H2S removal, it would be necessary to apply a dosage of 75 kg/d, which represents about 6% of the affluent mass to the biodigester (1212 kg/d).

Therefore, the application of Iron-Ox® Bio in the biodigester not only allowed to obtain the removal efficiencies predicted in the dosage calculations, but also did not cause any problems related to the generation and management of sludge, therefore being endorsed by the partner company. Furthermore, the sulfur and iron incorporated into the digestate and the sludge bring benefits to their subsequent application to the soil. In this way, the advantage is the application of a natural, 100% native product, with a low carbon footprint and lower cost compared to the chemical products commonly used.

SPATIAL DISTRIBUTION OF MANURE ON A VOLUNTARY MILKING PARLOR AND EFFICIENCY OF WASHING BY FLUSHING

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Knowledge of the distribution of manure from lactating cows on the floor of the milking parlor is essential for optimizing the washing routine and proposing best practices aimed at efficient use of water and the time spent by the operator in carrying out the washing practice. In recent years, the voluntary (robotized) milking system has been used in Brazilian feedlots, but its use in pasture systems is still an exception. This study aimed to evaluate the spatial distribution of manure on the floor of a robotic milking parlor in an integrated crop-livestock-forest system. The Delaval VMS™ V300 was installed at Embrapa Pecuária Sudeste, Sao Carlos-SP, where the animals have voluntary access at any time of the day to the milking system. The milking parlor floor was divided into five sections of equal area (A1, A2, A3, A4 and A5) and left and right sides. The manure was classified according to the form: whole (mass as it was mucked by the animal), partial (mass presented some alteration in its form as trampling, dragging, etc.), mud (demobilized mass in solid/liquid form), and, dirt (small amounts of manure spread on the floor). 30 events were monitored, where the distribution of manure in each section and side was recorded in a spreadsheet. The annotation was performed before and immediately after the “flushing” to evaluate the washing efficiency. The flushing water outlets were located on the A1. Sections A1 and A2 showed the highest concentrations of manure in whole and partial forms for both sides before and after washing. A1 is the area where the robot is located, with its entry on the right and exit on the left side, so due to this position there is a large concentration of animals in areas A1 and A2 that are waiting for their turn to access the equipment. A5 is the farthest from the robot and has the lowest concentrations of manure. Considering the whole manure, the maximum washing efficiency of the flushing was 75% for both sides in sections A3 and A4, respectively. In sections A1 and A2, with the highest concentrations of manure, the maximum efficiency of flushing was 56% (A1-left side), and the minimum 20% (A2-right side). Therefore, in these sections, even after flushing, a significant part of the manure remained, either in whole, partial, or mud form. The results show that for the washing parlor to be more efficient, other routines should be considered, such as scraping the floor before flushing or demobilizing the mass of whole manure in sections A1 and A2 before washing. The option of increasing the daily frequency and time of flushing would result in higher water consumption and effluent production, both not recommended.

CHARACTERIZATION OF DAIRY COWS DUNG IN A VOLUNTARY MILKING SYSTEM

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The animals, when accessing the milking parlor, have the behavior of dung on the floor. This residue must be removed daily to maintain the hygiene standards of the facility and the health of the humans and animals. Therefore, knowledge of physical characteristics such as diameter and weight of dung from lactating cows is essential to propose actions related to the management of this waste. This knowledge is not common in the technical literature, even more so when it comes to milking parlors with a robotic system and in an integrated crop-livestock-forest system. This study aimed to characterize the dung of lactating cows of a robotic milking parlor in an integrated crop-livestock-forest system. The Delaval VMS™ V300 was installed at Embrapa Pecuaria Sudeste, Sao Carlos-SP, where the animals have voluntary access at any time of the day to the milking system. 69 dung samples were collected. Immediately after the animal had dunged, the sample was measured in terms of diameter using a measuring tape. Then the dung was scraped off in its whole with a shovel and weighed on a scale. The average diameter of the dung was 28.4 cm (+/- 3.0 cm), with a minimum of 23 cm and a maximum of 38 cm. This average diameter is equivalent to an area of 0.0634 m2. From knowing the average diameter of the dung and the amount of it in the milking parlor, it is possible to calculate the total area occupied by the waste and thus optimize scraping and washing practices. The average weight of dung was 2.1 kg (+/- 0.5 kg), with a minimum of 1.3 kg and a maximum of 3.1 kg. It is known that the production of dung by an animal is the result of several factors such as genetics, feeding, installation, and management, among others. The mass of dung to be handled is important information for sizing storage structures and/or dung treatment systems. From the determination of what would be the standard dung of lactating cows, the decision-making on the management of this residue will be more assertive, which will mean a lower cost of this management.

CASE STUDY OF LIVESTOCK AND AGROINDUSTRIAL RESIDUES CO-DIGESTION

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This study was carried out in a laboratory scale, which allowed us to understand and predict the best scenario regarding the operation of a full scale biodigester using co-digestion of livestock and agroindustrial wastes. In order to find the best composition (blend) and process parameters to reach the best biogas recovery from the referred substrates. Thus, during 145 days, a CSTR laboratory scale reactor was operated at mesophilic conditions (37 ± 2 ºC), was submitted to anorganic loading rate (OLR) gradual increase, referring to a mixture of different substrates, in the proportions that will possibly be received in the full scale plant. Five substrates were used during the experiment: cattle and swine manure from livestock activities, in the ratio of 25:1 respectively, poultry hatchery residues, dissolved air flotation (DAF) sludge, and protein residues from the poultry and swine slaughter house industries, in the respective proportions 1.1:5.2:1. The reactor was started with a previously acclimatized anaerobic sludge and the OLR was increased whenever the biogas production was stabilized (less than 5% variation in biogas productivity and biogas yield for 5 days). At the beginning the reactor was fed only with swine and cattle wastes reaching an OLR of 0.35 kgVS m-3 reactor d-1. After process stability, the subsequent OLR progressions were performed using the three agroindustrial substrates, reaching an OLR of 0.85, 1.35; 1.88; 2.38; 2.58; 2.63 and 3.13 kgVS m-3reactor d-1, consecutively, resulting in 7 OLR progressions (8 phases). Until phase 4 (1,88 kgVS m-3reactor d-1), the reactor responded satisfactorily according to the OLR increase, resulting in a progressive biogas yield and productivity. In phase 5 (2.38 kgVS m-3reactor d-1), the biodigester started to present a process instability, the VFA/TA increased from 122 mgHAc mgCaCO3-1 (day 74) to 1041 mgHAc mgCaCO3-1 (day 95) and then gradually decreased to 571 mgHAc mgCaCO3-1 at the end of the phase (day 102). The pH decreased from 7.84 (day 74) to 7.51 (day 92) and then increased to 7.79 (day 104). Free ammonia (FA) started at 344 mgNH3 L-1 (day 74), decreased to 126 mgNH3 L-1 (day 88) and at the end of the phase was at 382 mgNH3 L-1 (day 102). The methane content in the biogas decreased from 69.6% to 63.9%, the biogas productivity decreased from 1.70 to 1.52 LN Lreactor-1 d-1 and biogas yield decreased from 0.83 to 0.64 LN gVSadd-1. After this period, biodigester operational parameters returned to stability conditions, which allowed the OLR increase. Despite the period of instability, the reactor presented good results for the studied residues co-digestion. In the initial phase in which the biodigester was fed only with swine and cattle wastes the biogas productivity reached a maximum result of 0.35 LN Lreactor-1 d-1, when the agroindustrial residues were added the biogas productivity reached 2.27 LN Lreactor-1 d-1 in the last phase (8), in the same way the biogas yield increased from 0.55 LN gVSadd-1 in first phase to 0.72 LN gVSadd-1 in phase 8.

ECONOMIC-FINANCIAL FEASIBILITY OF A PILOT TREATMENT SYSTEM OF SWINE MANURE

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The implementation of a pilot station for treat and monitoring of effluents aimed to guide producers, technicians and legislators involved in the swine production chain and also those related to the environmental area in decision-making about the environmental and economic viability of the activity, providing a reduction impacts on the natural resources of the PCJ Basin, savings from the reuse of water and the use and/or sale of organic compost and biogas, which may even provide alternative income to producers. This work aimed to analyze the economic and financial viability of a pilot system for treat of swine manure in an experimental farm with capacity for 160 finishing animals, in APTA/Piracicaba, SP, during 04 production cycles, 365 days, during the year 2018. The Net Present Value (NPV), the Internal Rate of Return (IRR) and the Capital Recovery Period (Payback) were used as economic result indicators. The economic viability analysis considered 6 scenarios for the effluents generated, namely: Scenario 1 - producer does not carry out any type of treatment, with the raw effluents generated applied directly to the agricultural soil; Scenario 2 - producer has homogenization tank and sieve, generating solid waste for composting and treated effluent applied for agricultural purposes; Scenario 3 - producer has homogenization tank, sieve and biodigester, generating solid waste for composting, biogas and treated effluent applied for agricultural purposes; Scenario 4 - producer has homogenization tank, sieve, biodigester and aerobic reactor, generating solid waste for composting, biogas and treated liquid effluent applied for agricultural purposes, Scenario 5 - producer has the complete system, generating solid waste (sieve and sludge) to composting, biogas and treated effluent applied for agricultural purposes or reuse water. Still, another scenario - scenario 6 - was analyzed, where the producer has the complete system (generating solid waste - sieve and sludge - for composting, biogas and treated effluent applied for agricultural purposes or reuse water), with the exception of the aerobic reactor, considering that this phase of the process did not show efficiency, according to the chemical analyzes carried out. The results, in nominal values for 2018, showed that only scenarios 2 and 3 were economically and financially viable, with a return IRR of 121% p.a. for scenario 2 and 20% p.a. for scenario 3 and return on invested capital in 0.8 and 1.9 years, respectively. After estimating the amount of nitrogen (Kg/annual cycle) in the effluents from the different treatment systems, the areas needed for annual crops of sugar cane, corn and pasture were estimated, in order to carry out the agricultural use of the effluents generated in properties that have different compositions of manure treatments. As more manure treatments are carried out, less available area was needed to dispose of this material.

ENVIRONMENTAL IMPACTS TO THE AIR, SOIL, WATER AND PLANT SYSTEM

LIFE CYCLE ASSESSMENT OF SOLAR PANELS USING CES EDUPACK SOFTWARE: DECOMMISSIONING IN 2030

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Solar photovoltaic energy is on the rise as a renewable source of electricity generation that plays a key role in diversification and represents 4,4% of the national energy matrix, with an estimated growth rate of 42% for the year 2023, reducing dependence on non-renewable sources and contributing to the mitigation of greenhouse gas emissions. Based on an estimate of the number of photovoltaic panels installed in the country and the amount to be installed by 2030, a projection was made of the average volume of waste generated throughout all phases of the life cycle of these panels. To assist in this process, the Eco Audit module of the CES Edupack software was used, which contains a large database with information on various types of materials, in order to verify the environmental footprint in the material and end-of-life phases, analyzing two important environmental tensors: the CO2 footprint and the energy expended. The possibility and possible recycling routes were described. With these results, it is estimated that almost all the components of the panels have the potential to be recycled and reused efficiently. In view of this, it is essential that a structured decommissioning chain is installed, where both the state and companies must organize themselves to deal with large-scale waste generation and create strategies for the correct destination, obtaining benefits from the opportunities in this area.

ASSESSMENT OF ENVIRONMENTAL ASPECTS AND IMPACTS IN BIOPOLYOL PRODUCTION USING LIGNOCELLULOSIC RESIDUES

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Using residual agricultural biomass as a feedstock in the production of chemical components and energy, such as biopolyols and biofuels, has emerged as an attractive solution to avoid petroleum based products. By employing raw materials sourced from renewable origins, these processes are believed to yield environmentally friendly products. However, it is essential to thoroughly study the production processes and product characteristics to assess potential environmental vulnerabilities, as certain "solutions" may inadvertently lead to the transfer of environmental problems. In light of this, the present study focuses on evaluating the environmental aspects and impacts associated with the production of biopolyols derived from the reuse of lignocellulosic biomass, specifically cassava peel. This study was performed in lab scale, in batch reactors, to produce 30 grams of biopolyol. The Potential Negative Environmental Impact Analysis (PNEIA) methodology was employed to identify seven environmental aspects that could adversely affect natural resources, such as water and electric power availability, and risks to air and water quality, soil health, and human. To apply PNEIA methodology, the biopolol production process was divided into five stages: drying and grinding of the biomass, liquefaction, filtration and drying of the biopolyol. The result obtained for the liquefaction yield was 80.9 % wt. and it demonstrated this process is promising for the conversion of cassava peel biomass into biopolyol. As a result from PNEIA, it was found that the significant environmental aspects involved in the laboratory production of biopolyol are the emission of particulate matter, the generation of liquid effluent (dangerous), the generation of solid waste (dangerous) and the generation of noise. In this study, electricity consumption was not classified as a significant environmental aspect. Although it was significant in the drying stages (in an oven) of the biomass and the liquefied product (biopolyol). By identifying and addressing environmental risks, the results of this study offer valuable insights for the planning of large-scale biopolyol production and technological advancements in the process. The world seeks for sustainable solutions: the adoption of renewable resources for chemical and energy production is vital. However, to ensure the true environmental benefits of these solutions, a comprehensive understanding of their potential impacts is indispensable. The findings of this study shed light on the critical environmental aspects associated with biopolyol production, paving the way for the development of environmentally responsible processes.

NITROGEN USE EFFICIENCY FROM SLAUGHTER TO BEEF CONSUMPTION IN BRAZIL

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Nitrogen is an essential element for the development of plants and animals, but its improper use has caused environmental impacts such as eutrophication, greenhouse gas emissions, and contamination of surface and groundwater. Therefore, this study aims to assess the efficiency of nitrogen use from slaughter to beef consumption between 2011 and 2021 in Brazil. For this, data from the Brazilian Institute of Geography and Statistics (IBGE) regarding slaughter research and the Brazilian population were used, as well as information on the amount of nitrogen present in beef, leather, tallow, viscera, blood, manure, slaughterhouse residues, food waste, and human excreta. Nitrogen flows throughout the supply chain were quantified using material flow analysis methodology. Both the nitrogen use and accumulation were estimated by applying nutrient use efficiency (NUE) and nitrogen cascade indicator (NCI). In the slaughter phase, the NUE was calculated by taking the ratio between the amount of beef and the produced co-products (leather, tallow, blood, and edible viscera) together with the inputs of nitrogen from the slaughter animals. While in the beef processing, the NUE was calculated as; the ratio between the beef consumed by Brazilians and the total beef available for consumption. Whereas in the consumption phase by the Brazilian population, the NUE was estimated from the ratio between the population's nitrogen stock and the total amount of beef consumed by Brazilians. The NCI was calculated for the entire production chain, considering the sum of nitrogen loss across the slaughter, beef transport to storage, human excreta and waste upon the consumption, divided by the totally produced beef. The slaughter phase presented a highest NUE that remained constant at 90% throughout the study period. The beef processing phase exhibited the second-highest efficiency, with NUE values ranging from 79% (2012) to 88% (2021) across the years. The beef consumption by the Brazilian population had the reduced NUE, ranging from 29% (2021) to 34% (2013) during the study. NUE values above 90% indicate high efficiency in nutrient use, while values below 50% indicate low efficiency. So, the NUE analysis demonstrated the possibilities for further upgrade in the beef consumption efficiency by the Brazilian population. In terms of the cumulative effect of nitrogen in the Brazilian beef slaughter and consumption, the NCI was estimated at 77% (2021) to 82% (2011), highlighting the accumulation of nitrogen in the production chain. The low efficiency observed in beef consumption, coupled with the potential cumulative effect of nitrogen throughout the production chain, can magnify the local-scale environmental impacts of nitrogen. Therefore, measures of food waste reduction in combination with the factors like close proximity in livestock, agroindustry and consumers, can open doors for nutrient circularity, and improvements on use efficiency and accumulation.

INDICATORS OF DAIRY WASTE IN SOUTH AMERICAN COUNTRIES TO STIMULATE THE CIRCULAR ECONOMY

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The aims of this study were quantify and qualify the dairy wastes in some South America countries to stimulate programs and policies in circular economy. Four South America countries were considered in this study: Argentina (A), Brazil (B), Chile (C), and Uruguay (U). The reference year to quantify and qualify the dairy wastes produced by each country was 2018 and calculations only considered the intensive mixed crop–livestock systems and manure produced per lactating cows. Secondary data locally available from various sources (country official statistics, scientific articles, and experts' estimates) were collected. These data were: total number of lactating cows, total milk production (kg, Fat and Protein Corrected Milk), average milk yield (L.cow-1.day-1). The equations proposed by Nennich et al. (2005) were accounted to calculate the Total Manure Excretion (ME), Manure Dry Matter Excretion (DME), Nitrogen (N), Phosphorus (P), and Potassium (K) Excretion. From these calculations the following indicators were evaluated: kg manure cow-1.day-1, kg dry mater.cow-1.day-1, kg N–P–K.cow-1.day-1, g manure.L milk-1, g N–P–K .L milk-1. B and A presented the highest milk production and number of lactating cows and U had the highest average milk yield, 18.8 kg cow-1.day-1. The total manure excretion per cow per day was 57.5, 56.3, 52.8, and 50.2 kg to U, A, C and B, respectively. The percentage of DME varied from 12.3% to 12.5%. The ME in Ton.day-1 was 306,536 to B, 94,525 to A, 24,056 to C, and 18,251 to U. These corresponded a daily N availability of 2,224 Ton in B, 659 Ton in A, 171 Ton in C, and 126 Ton in U. P daily availabilities were 339, 106, 27, and 21 Ton to B, A, C, and U, respectively. U produced the highest nutrients excretion (per cow-1.day-1) 0.398 kg N, 0.065 kg P, and 0.181 kg K. Brazil had the lowest (per cow-1.day-1) 0.364 kg N, 0.056 kg P, and 0.164 kg K. To each litre of milk produced per cow per day in 2018, B generated 7.7 kg of manure, C 4.9 kg, A 3.4 kg, and U 3.1 kg. The values presented show the potential to recycle/reuse dairy waste as fertilizer on pastures and crops in these countries. These practices will contribute to improve the soil fertility and reduce the use of chemical fertilizers. The availability of nutrients and the prevailing production profile in these countries (mixed crop-livestock intensive system) should be incentives to internalize the "circular economy" in this sector. Dairy efficiency aspects influence the quantity of waste and the nutrients availability in it. It was identified in the dairy waste indicators calculated to each country. The authors are aware of the uncertainties in the estimates. However, we believe that it is useful to have a first approximation to compare the amounts of dairy waste produced in each country and use these results as potential information to stimulate the management of livestock production systems in a "circular" manner.

MSW PYROLYSIS: A PROPOSE FOR REDUCTION LANDFILL DISPOSES

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The disorderly world's growth population has contributed to scarcity of natural resources and the increase in the disposal of municipal solid waste (MSW). At a global level, the use of landfills as a most common way to dispose of MSW. In these landfills, a combination of physical-chemical and microbiological processes occurs, promoting the transfer of pollutants from the disposed material to soil, which may percolate to the groundwater. According to the National Sanitation Information System, SNIS (Brazil, 2022), in 2020, 65.29 million tons of MSW were sent to landfills, including sanitary landfills, controlled landfills and dumps. The areas occupied by the disposal of MSW end up, occupying territorial spaces that could be used for other activities, including agricultural. However, after disposal of this waste, the areas cannot be used for these purposes. The reduction of waste discarded in this format is essential for the preservation of life on the planet. Technologies aimed at the energy recovery of MSW, having proven its technical and environmental viability, is a sustainable option to be implemented for its destination. When subjected to thermochemical processes, especially pyrolysis, the MSW volume can be reduced by more than 90%. Pyrolysis is a process of thermochemical decomposition of a given material in the absence of oxidizing agents, where complex hydrocarbon molecules are decomposed into relatively smaller molecules. The products of pyrolysis are a non-condensable gas (CO/H2/CH4/CO2), condensable vapors and a carbonaceous solid (char). Char is the solid product of pyrolysis, composed mainly of carbon (~85%), and may contain other elements due to the composition of the raw material used. The char has unique properties (high stability, carbon content, porosity and surface area) which promotes an improvement in the quality of the chemical composition of the soil, adsorbing organic and inorganic pollutants and, due to its stable structure, stores carbon (sequestration) for periods longer than 1,000 years. It is observed that, in addition to reducing the amount of material for final disposal in the soil, the solid product obtained from the pyrolysis of MSW can act as a soil improver, promoting an increase in the nutrient content and stability of aggregates in the soil, which makes it possible to reduce the use of chemical fertilizers, improving the sustainability of cropping systems. This study evaluated the MSW pyrolysis process in a micro-region, made up of 32 municipalities, located in Rio Grande do Sul/Brazil. The results obtained demonstrate that the amount of material to be destined for the soil, in the form of landfills, or in the application in arable areas, reduces by 70%. This data indicates that more than 45 million tons of waste, nationwide, would no longer use the soil for disposal. Also, the remaining volume would not compromise soil quality, since it is a stable product.

WASTE TO ENERGY

VALORIZATION OF EXPIRED DAIRY PRODUCTS FROM BRAZILIAN AGROINDUSTRIES IN HYDROGEN PRODUCTION BY DARK FERMENTATION

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The dairy industry is among the pillars of the agroindustry, with global production of 928 million tons of milk in 2021. Several dairy products are wasted after their expiration date. A sustainable alternative for recovery and valorization of this waste would be their application for H2 production. This study evaluated the co-digestion of expired dairy products (EDP) with synthetic sewage (SS) in assays composed of (v/v): (1) 10% EDP + 90% SS, (2) 15% EDP + 85% SS, and (3) 20% EDP + 80% SS to evaluate the hydrogen (H2) production via dark fermentation. Anaerobic batch reactors (1.0 L) were assembled in duplicates with 0.5 L headspace (N2 99.99%), and a working volume of 0.5 L filled with 19 g VS L-1 of heat-pretreated granular sludge (100 ºC for 15 min), 5 g L-1 NaHCO3, with initial pH 6.5, at 37°C, in a static mode. The monitoring of the reactors was carried out from the analysis of biogas generation and soluble metabolites, in addition to carbohydrate removal. Identification of the inoculum was performed using the large-scale molecular biology technique. The cumulative H2 productions in 107 hours of operation were (mL Lr-1) 652.6, 1023.4, and 1309.3 for the assays (1); (2), and (3) respectively, demonstrating that the volume of H2 increased proportionally to the amount of EDP in the assays. The carbohydrate removal also increased equivalently with increasing EDP in assays 1, 2, and 3 with 86.8%, 90.1%, and 92.3%, respectively. The highest H2 yield was obtained for Assay 2 with 1.9 mol mol-1 carbohydrate removed, followed by Assay 1 and 3 with yields of 1.7 and 1.5 mol mol-1 carbohydrate removed. The production of H2 occurred simultaneously with the generation of different soluble metabolites. At the end of the operation, butyric acid was the main soluble metabolite in all assays with concentrations of (mg L-1): 1,695.1, 2,384.8, and 2,557.1, for assays 1, 2, and 3, respectively. Other soluble metabolites were detected in all assays, such as acetic acid (1,083.4 – 1,268.7 mg L-1), ethanol (181.6-327.7 mg L-1) propionic acid (257.3-342.7 mg L-1), isobutyric acid (74.3-185.9 mg L-1), isovaleric acid (87.0-246.8 mg L-1) and caproic acid (88.2-190.1 mg L-1). The final pH values were 6.2, 5.7, and 5.5 in assays 1, 2, and 3 respectively. Paraclostridium was the genus identified with the highest relative abundance of 55.7%, 77.8%, and 82.7% in assays 1, 2, and 3, respectively. This genus was positively correlated with fermentative reactors since it could metabolize carbohydrates from EDP producing H2 and volatile fatty acids. Therefore, it contributed to the high carbohydrate removal efficiencies and high hydrogen yields observed in the present study. The results obtained demonstrated viability in the application of EDP and SS, by dark fermentation, obtaining hydrogen as a biofuel.

APPLICATION OF THERMAL AND ACID PRETREATMENTS IN GUAVA AGRO-INDUSTRIAL WASTE TO METHANE GENERATION IN ANAEROBIC BATCH REACTORS

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Brazil has the largest amount of guava production in the world, a fruit that is used in several products from the pulp. The processing of guava generates a significant amount of organic waste that can lead to environmental problems due to inadequate disposal. A possible solution is to use these residues to produce biogas from anaerobic digestion. Thermal and acid pre-treatments have been applied to agro-industrial residues to release carbohydrates present with consequent generation of methane by biological processes. The residues generated from the industrial processing of guava provided by the food industry that produces guava sweets and jellies (Predilecta Alimentos – São Lourenço do Turvo, Matão, SP, Brazil) were used as carbon source. Firstly, thermal pre-treatment of industrial guava residue was carried out in autoclaving, carried out with borosilicate bottles with a total volume of 1L, containing 700ml of residues, separately, with additions of H2SO4 (1% and 5%), in duplicate, at 120ºC in a pressure of 1 kgf/cm² maintained for 30 minutes. Synthetic sanitary sewage was used as a diluent in co-digestion processes in the assembly of duplicates of anaerobic batch reactors. Anaerobic granular sludge from a UASB reactor (Upflow Anaerobic Sludege Blanket), used in the treatment of waste from poultry slaughter (Avícola Dacar Ltda. – Tietê, SP, Brazil) was used as inoculum.The reactors (1L) were filled with substrate/inoculum ratio 1.0, fixing 15g COD/L and 15g VS/L. The buffer solution in 5g NaHCO3/L were added in the reactors. The initial pH was fixed in 7.0 and the reactors were submitted to a N2 atmosphere (99.99%) for 10 min after the distribution of the solutions. After that, they were capped with butyl rubber stoppers, wrapped and kept at 37 ºC ± 1 ºC, with agitation at 120 rpm operated during 61.5 h. Control reactor without pre-treatments and Endogenous reactor without substrate addition were assembled in the same conditions. Samples were collected for analysis of COD and carbohydrates by colorimetric method. Quantification of biogas was made by volumetric displacement. The experimental data were adjusted using the software Statistica® (version 8.0). The maximum rate of biogas production was obtained by non-linear sigmoidal adjustment of the modified Gompertz function. The thermal pretreatments with addition of 1%, 5% of H2SO4 were efficient to release carbohydrates in 928mg/L, 959mg/L, respectively. These results were higher than the control that contained 375mg carbohydrates/L. The COD consumptions were 77,40%, 68,19% and 80,22% to reactors with guava residues pretreated with 1% H2SO4, 5% H2SO4 and control reactors, respectively. Accumulated methane production presented no significant difference between 1% and 5% of H2SO4 (1333 mL CH4/Lr and 1460 mL CH4/Lr, respectively). However, there was an improvement in methane generation compared to the control reactor (1223 mL CH4/Lr). The methane production rates did show significant differences between the 1% H2SO4 (169,89 mL CH4/Lr/d) and 5% H2SO4 (131,04 mL CH4/Lr/d). Thermal pre-treatments with acid additions increase the release of carbohydrates and can be applied to agro-industrial residues aiming at higher biogas generation.

ENVIRONMENTAL EVALUATION OF ANAEROBIC DIGESTION FOR TURKEY LIVESTOCK MANURE: A LIFE CYCLE ASSESSMENT

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Turkey litter consists of organic material, such as straw or sawdust, used as a substrate in poultry housing and is often used as fertilizer. This material has two essential functions, improve the housing ambiance of turkeys and absorb the excreta. However, the decomposition of this material produces a large amount of waste and emits greenhouse gases such as methane. Waste management and greenhouse gas emissions are problematic and interlinked issues. The increase in waste production and its inadequate disposal, coupled with the need for alternative energy sources, has fostered anaerobic digestion technology as a sustainable alternative that contributes to reducing emissions and generating renewable energy. In this sense, this study evaluated the environmental feasibility of anaerobic digestion of turkey litter through a life cycle assessment and compared it with the traditional use of litter as fertilizer. The study's scope covered two scenarios analyzed. The first was turkey litter stockpiling and field application. The second was biogas production, with cogeneration of electricity and heat, followed by storage and application of digestate as fertilizer. The functional unit was 1 tonne of turkey litter. The inventory was built on data collected from the literature. ReCiPe Midpoint 2016 was the methodology for environmental impact assessment used. Based on the results, anaerobic digestion proved to be environmentally favorable to mitigate the environmental impacts caused by turkey litter handling. The energetic utilization of turkey litter was able to mitigate 67% of greenhouse gas emissions, compared to traditional management, which presented a global warming potential of 408.64 kg CO2eq per ton of turkey litter. These results highlight the significant potential of employing anaerobic digestion for turkey litter and emphasize how proper waste management can ensure the environmental viability of agricultural practices.

COMPARATIVE STUDY OF HYDROGEN PRODUCTION AND OTHER VALUE-ADDED PRODUCTS BY ISOLATED CULTURES AND CO-CULTURES FROM RAW GLYCEROL

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Despite biodiesel being a renewable energy alternative, the ideal management of raw glycerol still requires adequate environmental management. The use of this residue for the bioproduction of hydrogen (H2) and metabolites is an alternative for the use of glycerol. Hydrogen does not generate polluting gases during combustion, and facultative and strict anaerobic microorganisms are capable of producing this biofuel through fermentation.The conversion of residual glycerol can be performed by the association of two or more microorganisms in the fermentation process, called co-culture. The efficiency of hydrogen production depends on the performance, synergy and complementarity of microbial metabolic pathways. Thus, pure cultures of Bacillus subtilis (BS), B. rugosus (BR) and Clostridium bifermentans (CB) and co-cultures of these microorganisms were evaluated for the production of hydrogen and soluble metabolites, using raw glycerol as substrate. The assays were carried out in 600mL flasks, containing 300mL of 3% glycerol culture medium at pH 6. Microorganisms were evaluated separately and in co-cultures: BS+BR, BS+CB, BR+CB, BS+BR+CB. Microorganisms were isolated from hydrogen-producing anaerobic sludge and identified. The flasks were kept in agitation for 72h, 140rpm at 37ºC to determine the concentration of H2, soluble metabolites (acids and alcohols) and consumption of raw glycerol. Hydrogen production was determined using gas chromatography. The concentration of soluble metabolites was determined using High Performance Liquid Chromatography – HPLC. Glycerol consumption was determined using a colorimetric method. The highest efficiency with 47% glycerol consumption and high H2 yield (0.29 mol H2 / mol glycerol) was obtained for B. subtilis. The different combinations of microorganisms in the co-cultures did not increase the consumption of glycerol and the yield of hydrogen was lower than that obtained by the microorganisms alone. The generation of ethanol and butyric acid was predominant among the isolated microorganisms, demonstrating favoring the oxidative metabolic pathway. For the co-culture (BR + CB) the high generation of ethanol (2.8 g/L) stood out. While, the butyric metabolic pathway (2230 mg/L) was prevalent for BS + CB. The highest generation of 1,3 propanediol was from CB+BS (1.5 g/L). The selection of strains with potential for the production of H2 and value-added products shows promise for decarbonization processes and sustainable energy development. Finding organisms capable of producing hydrogen and other compounds of interest that tolerate impurities found in raw glycerol is the main challenge and the use of co-cultures is attractive for reducing costs in large-scale processes for the production of hydrogen and compounds of economic value.

DISTRIBUTED MICROGENERATION AND MINIGENERATION IN BRAZIL: ADVANCES AND CHALLENGES IN THE UTILIZATION OF AGRICULTURAL WASTE AS A RENEWABLE ENERGY SOURCE

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Normative Resolution 482, issued on April 17, 2012, introduced Micro and Minigeneration Distributed (MMGD) in Brazil, with a maximum capacity limit of 75 kWp for microgeneration and 5 MWp for distributed minigeneration. This new modality distinguishes itself from Distributed Generation not only in terms of power limits but also in its operational proximity to the load and remuneration through the net metering regime. Instead of receiving a monetary value equivalent to the injected energy in kilowatt-hours (kWh), energy producers in this category are compensated with kWh credits. Moreover, in order to be eligible for the MMGD scheme, the primary energy source must be renewable or qualified cogeneration, including photovoltaic, wind, small hydropower, bioenergy thermal power plants, and natural gas.

Over a decade since the publication of REN 482/2012, which has undergone subsequent updates through REN 687/2015 and the "Legal Mark for Distributed Generation" regulated by REN 1059/2023, the photovoltaic MMGD market has flourished. However, the adoption of other energy sources, such as agricultural waste, remains limited within the electricity sector. ANEEL data reveals that, as of June 30, 2023, out of the 2,018,552 MMGD units in Brazil, 2,017,857 are based on solar photovoltaic technology. Additionally, there are 467 biogas plants, including 16 utilizing forestry waste, 335 utilizing animal waste, 81 utilizing urban waste, and 35 utilizing agro-industrial waste. Other sources of agricultural waste employed include sugarcane bagasse (16 units), rice husk (5 units), forestry waste (7 units), and municipal waste (5 units). Furthermore, there are 95 wind energy units, 80 hydropower units, 12 natural gas units, 7 biomass units utilizing blast furnace gas, and 1 firewood unit. In terms of installed power (kW), urban waste accounts for less than 0.2% of the total, while rural waste, including various biogas sources, bagasse, rice straw, and forestry waste, represents less than 0.5% of the total installed MMGD power in the country.

Despite the improvements brought about by the Legal Framework for Distributed Generation, the current incentive system has proven insufficient for the development of energy sources that utilize agro-industrial waste. The utilization of such waste offers sustainability benefits by tapping into rejected materials as primary energy sources, thereby optimizing the production chain and mitigating environmental impacts. Additionally, this approach enhances the value of regional specificities, such as utilizing rice straw in the South and sugarcane bagasse in the Southeast, contributing to regional development and an improved quality of life in rural areas. However, due to higher installation costs, the need for specialized projects, and a lower modularity compared to photovoltaic sources, the utilization of agricultural waste may pose less economic appeal under the current incentive regime. These circumstances underscore the importance of more specific regulations that consider regional characteristics, primary energy sources, consumption classes, as well as social, economic, and environmental externalities. Such regulations are vital to fostering a comprehensive and balanced incentive framework for MMGD across Brazil, a country renowned for its diverse energy potentials.

EVALUATION OF THE MICROBIAL AND FUNCTIONAL POTENTIAL OF DIFFERENT INOCULA FOR ANAEROBIC DIGESTION PROCESS

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Due to the current climate crisis, there is an increasing interest in developing sustainable alternatives for energy production. One promising avenue is the use of anaerobic digestion (AD), a process that converts various types of waste and effluents into biogas. The AD process consists of different stages performed by specific microorganisms. Groups of bacteria carry out hydrolysis to generate fatty acids, which serve as precursors for the methanogenesis stage, where archaea produce methane. To maximize the efficiency of these processes, it is crucial to understand the complex dynamics of microbial communities participating in the conversion of these wastes into energy. The present study conducted a comparative analysis of the taxonomic characterization and functional metabolic prediction of inocula used in different AD works. The objective was to investigate how the variation in microbial diversity can guide the selection of suitable inocula for specific substrates and wastes, thereby optimizing the bioconversion process. Samples from a granular sludge inoculum from brewery effluent treatment (ACoD), a swine and cattle manure inoculum (LS), and another inoculum formed by the decomposition of urban solid waste, along with customs seizures (IU) in the border region, were evaluated. DNA extraction was performed using the DNeasy PowerSoil kit. The samples were analyzed using next-generation sequencing (Illumina Miseq) of the V3-V4 regions of the 16S rRNA gene for the Archaea and Bacteria domains. Sequence processing was carried out using bioinformatics tools from the Qiime2 software, and taxonomic annotation was performed using the SILVA database. Functional prediction analyses were obtained using the PICRUSt2 and BURRITO software with gene inference using KEGG Orthology. The results showed that the granular inoculum (ACoD) exhibited a higher abundance of Desulfobacterota, comprising over 50% of the microbial community in the sample, followed by Halobacterota (20%) and Euryarchaeota (8.14%). Despite the high abundance of methanogenic microorganisms in the sample, Desulfobacterota includes sulfate-reducing bacteria that compete with methanogenic archaea, potentially leading to a negative impact on biogas production. The LS inoculum revealed a significant presence of Synergistota (36.3%), followed by Firmicutes (37.36%) and Chloroflexi (9.7%). These phyla are capable of hydrolyzing complex compounds, facilitating the production of volatile fatty acids needed for methanogenesis. The IU inoculum samples showed a higher abundance of phyla, with a predominance of Bacteroidota that decomposes cellulose into cellobiose and glucose, indicating an advantageous inoculum for cellulose-rich substrates. All samples exhibited the presence of essential genes such as Acetyl-CoA synthetase, acetyltransferase phosphate, and acetate kinase, which are closely related to the acetoclastic pathway, as well as formylmethanofuran dehydrogenase, coenzyme F420, and 5,10-methylenetetrahydromethanopterin, associated with the hydrogenotrophic pathway. Understanding the complex functions and interactions of microorganisms enables the careful selection of inocula based on their proficiency to degrade specific substrates. In this way, we can improve these processes and enhance biogas production, consequently taking significant steps in mitigating environmental impacts.

APPLICATION OF PRE-TREATMENTS WITH ACETIC ACID IN AGRO-INDUSTRIAL RESIDUES TO BIOMETHANE PRODUCTION

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Guava residues generated in industrial processing are rich in cellulose and lignin from the peels, which can retain the release of carbohydrates and make it difficult to reuse them to generate biogas. Acid and thermal pretreatments of biomass are used to hydrolyze hemicellulose and cellulose and they can facilitate a subsequent enzymatic hydrolysis of these polymers to carbohydrates. This study tested thermal pretreatment with additon of acetic acid on guava residues to verify their efficiency in releasing carbohydrates for methane production by anaerobic digestion. The residues generated from industrial processing of guava used as substrate were from an agroindustry producing sweets and jellies (Predilecta Alimentos – São Lourenço do Turvo, Matão, SP, Brazil) and they containing: 262.67 g total COD/L, 222.33 g soluble COD/L, total solids (3.021g/L), total fixed solids (0.055g/L), total volatile solids (2.965g/L), pH (4.44) and total carbohydrates (87.73 g/L). After that, the guava residues were pre-treated at 120°C for 45min with acetic acid in the proportions of 10% and 20%, separately. The inoculum was from a UASB (Upflow Anaerobic Sludge Blanket) reactor used in the treatment of waste from poultry slaughter (Avícola Dacar Ltda. – Tietê, SP, Brazil) with total solids (1.080g/L), total fixed solids (0.152g/L) and total volatile solids (0.928g/L). Previous enrichment of the inoculum was also carried out, in a specific culture medium for methanogenesis. Synthetic sanitary sewage was used as a diluent in co-digestion processes in the assembly the reactors. Duplicates of anaerobic batch reactors (1 L) were filled with 0.5 L of reaction phase containing pre-treated guava (15 gCOD/L)+synthetic sanitary sewage +inoculum (20%) and headspace (0.5 L) filled with N2 99.99%, initial pH 7.0, 5 g NaHCO3/L, at 37°C, at 120 rpm for 18 days. Control reactor without pre-treatments and Endogenous reactor without substrate addition were assembled in the same conditions. Samples were collected for quantification of biogas (volumetric displacement method), removal of organic matter in COD and total carbohydrates analysis (colorimetric method) during the operation. The total carbohydrates were higher in pretreatments with addition of 10% and 20% of acetic acid (2515 and 3170 mg/L) than without pretreatments (1000 mg/L). The reactors with pretreated guava residues in 10% and 20% of acetic acid and control showed removals of total COD (69.97%, 45.00%, 65.70%), carbohydrates (81.66%, 66.16%, 72.73%) and the maximum methane generation (mL) 2495.0, 630.0 and 1547.5 with yields (mL CH4/g COD consumed/L reactor) of 1351.0, 763.64 and 902.33, respectively. The maximum biogas production rate (mL CH4/L reactor) and the maximum velocity of methane production rate (CH4/Lr/h) for reactors pretreated with 10% and 20% of acetic acetic and control were (2527.12; 702.58 and; 1481.40) and (9.83; 1.84; 8.81) respectively. Thermal pre-treatments with addition of acetic acid increased the release of carbohydrates and these strategies can be applied in agro-industrial solid residues such as guava for greater biogas generation. The next steps will be to test different proportions of acetic acid in termal pre-treatments to obtain better efficiences on carbohydrates liberation with high efficiences in methane production.

COMPARISON OF DIFFERENT NUTRIENT SOLUTIONS FOR BIOGAS PURIFICATION USING A BIOTRICKLING FILTER

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The population growth requires an increase in food production and energy availability, which leads to an increase in the productive demand of the agricultural and farming sectors. Consequently a greater generation of waste. Therefore, it is necessary to think about strategies for managing and treating this waste. One of the treatment strategies applied to agricultural waste is Anaerobic Digestion (AD). AD is a biological process where associations of microorganisms convert organic matter into biogas. Biogas is a mixture of gases that has an average of 65% CH4, 35% CO2 and trace concentrations of other gases such as hydrogen sulfide (H2S), which even at low concentrations must be managed due to human health and equipment toxicity and corrosiveness, respectively. Desulfurization can be done by physical, chemical or biological processes. Due to the low cost of implementation, the high efficiency, biological desulfurization processes are feasible and applicable. For biological processes, the biotrickling filter (BTF) stands out, due to its high removal capacity and low implementation and operating costs. In this biological process nitrate is one of the electron acceptors, which is supplied from commercial reagents. As alternative is to use a nitrate-rich solution obtained from a biological nitrification/denitrification treatment process. Thus, in this work, kinetic desulfurization was compared, on a real scale BTF, using NO3- from two sources: from effluent of an aerobic biological reactor (ABR) installed in the Swine Manure Treatment System (SMTS) at Embrapa Swine and Poultry; and using a synthetic medium solution prepared with commercial NaNO3. The BTF used in the study was previously acclimatized for 57 days. The kinetic studies were conducted in 6 days batches, with an continuous biogas flow average of 10 m-3 d-1 (1400 ppm of H2S). The nutrient solution was completely renewed at the beginning of each batch. The parameters evaluated were: removal efficiency (RE), elimination capacity (EC), pH, nitrate consumption and NO3--N/H2S ratio. For the first experiment was used ABR effluent containing NO3--N = 388 mg L-1 and Alkalinity = 432 mg CaCO3 L-1 (EC= 1,40 gH2S m-3 d-1, ER= 98,2%) and the second synthetic solution containing NO3--N = 389 mg L-1 and Alkalinity = 435 mg L-1 (EC = 1,49 gH2S m-3 d-1, ER= 96,2%). The NO3--N consumption rate obtained using the pseudo-first order kinetics by the modified Akaike model and described as: C(t)= C_0 e^(-kt) (mol L-1). The coefficients were obtained by linearizing the equation and applying the least squares method. The following equations found were C(t)= 388,13e^(-0,2498t) with R^2=0,9558 and C(t)= 388,88e^(-0,6356t) with R^2=0,9858 with the resulting the molar ratios (molNO3-N/molH2S) of 0.1035 and 0.1093 for the ABR effluent and the synthetic medium respectively. The results corroborate to demonstrate that the NO3- from the aerobic biological process can be an alternative supply as nutrient medium solution for biogas desulfurization via BTF, since the results obtained were similar for both cases. This work was funded by the TECNOVA/FAPESC program.

FOAM MITIGATION TREATMENTS IN BIOGAS GENERATION

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The search for alternatives aimed at using cleaner energy is increasing every day. In this context, biogas has stood out as a renewable fuel option. Its production occurs with the anaerobic digestion of organic matter; however, foam generation is a recurring problem in biogas plants that can harm the entire biofuel production process with damage to equipment, safety risks, and economic losses. Among the options to contain this problem are the addition of chemicals, such as dispersants and antifoams, and pre-treatments with enzymes. In this sense, this study aimed to verify the efficiency of these three treatments for foam mitigation in biogas production, in addition to comparing two forms of antifoam application in terms of foam reduction. The substrate used for evaluation comprises 8.91% organic matter (wet basis), of which almost 70% is protein. The tests were carried out following the experimental design of 2^3 type and central points, using a Microcontrolled Jar Test equipment. The test conditions covered a total time of 15 minutes, room temperature, stirring at 110 rpm, N2 flow rate of 3.5 L/min, 1 L of digestate and substrate diluted to 1% of organic matter. The height of the foam was checked five times during the test to observe the speed of increase. The enzymatic pre-treatment of the substrate was carried out with Protease enzyme for 1 hour, in proportions of 0, 100, and 200 g protease/ton substrate. The tests evaluated assays with 0, 1, and 2 mL of each additive for the dispersant and antifoaming agent analysis. The dispersant was always added before the beginning of the experiment, and the antifoam was added in two different procedures: before the beginning of the experiment and after 3 minutes. The results of the tests demonstrated that the lowest foam height was obtained in the assays that combined the addition of antifoam and pre-enzymatic treatment in their highest amounts. On the other hand, the highest foam heights were found in tests with little addition of both chemical and enzyme agents. As for the comparison between the treatments separately, the application of the antifoam and the enzymatic pre-treatment generated better results, and the application of the dispersant alone was the least effective. Regarding the way of applying the antifoam, it was not possible to notice a pattern for results in the application of the antifoam before or after foaming, with the final values of both procedures being similar, but apparently with the possibility of obtaining advantages by applying the defoamer after foam start. Thus, this study demonstrates the potential of applying antifoam and pre-enzymatic treatment in mitigating foam from anaerobic digestion of waste with high protein content, helping to avoid risks and losses in biogas production.

EVALUATION OF METHANE PRODUCTION IN POULTRY LITTER USING GRANULAR INOCULUM AND BIOAUGMENTATION WITH *ENTEROCOCCUS* SP.

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Brazil is the third largest chicken producer in the world and the 1st in exports, with 4.6 million tons of chicken meat exported in 2021. The poultry litter resulting from this activity has high concentrations of nitrogen, which can cause damage to the environment. Thus, the reuse of this residue for the generation of biogas is an alternative for the growth of the poultry sector. However, as it is a lignocellulosic residue, a biological treatment is necessary to accelerate the process. The granular inoculum has methanogenic potential, and the addition of other specific microorganisms, such as Enterococcus, acts in the management of hydrogen and volatile fatty acids (VFAs) and can speed up steps that precede the process. This study evaluated the anaerobic co-digestion of poultry litter and improved granular inoculum with two strains of the genus Enterococcus (H8 and V13). The isolates were grown in liquid Luria-Bretani (LB) medium and inoculated in the bioassays at a concentration equivalent to 0.3 OD (optical density), together with 25g. L-1 of poultry litter (PL) and 10% m/v of granular inoculum (S). For the control assays, only PL and S lived were added. Bioaugmentation increased methane production by 1.5X with the H8 strain and 2.4X with the V13 strain compared to the control, at the end of 30 days. There was a longer lag phase and partial reduction of volatile fatty acids in the augmented assays. These results are promising, showing possibilities of biological treatment with the bioaugmentation of isolates in poultry litter, helping hydrolyze these substrates and increasing methane production for later use in the poultry sector.

METHANE PRODUCTION FROM CASSAVA BAGASSE RESIDUE AND ITS ENERGETIC REPRESENTATION IN THE STATE OF PARANÁ

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Cassava (Manihot esculenta) is one of the crops expanding in tropical areas, used in human and animal food and as an industrial input. Brazil is the country with the sixth most significant production of cassava roots in the world, with the region of Paraná being home to 42 out of the 71 starch factories in the country, which represents approximately 14,000 tons of processed cassava roots and around 100 tons of agro-industrial waste per day. During processing, 40 to 90% of the mass of fresh cassava roots is estimated to be converted into residues rich in carbohydrates as cassava bagasse (CB). This material, rich in easily available carbohydrates, can be used in biotechnological processes, such as biogas production from anaerobic digestion. This study aimed to evaluate the methane production from cassava residues in this context. For this purpose, CB was tested in biochemical methane potential (BMP) assays. Approximately 200 g of inoculum obtained from a local anaerobic digester was added to 600 mL glass bottles and, after the degassing, were fed with sample (CB) at a 4:1 inoculum to sample volatile solids ratio and resealed. Some flasks were fed with microcrystalline cellulose, a standard used as a reference sample with known biogas potential, and flasks not fed composed a zero sample. The flasks were incubated at an orbital shaker-incubator, set to 40 °C and 150 rpm, with daily pressure readings taken using a pressure transmitter, followed by a purge of the excess gas produced until atmospheric pressure is achieved. The methane content was analyzed via gas chromatography (Agilent 6890A GC, HP-PLOT Q column, and thermal conductivity detector). The BMP assays were performed in triplicate. The results showed that CB has approximately 86% organic matter, 1.0% protein, and 0.8% lipids and presented a theoretical methane potential of 320 Nm^3CH4 tOM-1. Therefore, it was found that in the BMP assays, methane production increased by approximately 14% compared to the estimated theoretical production for the anaerobic digestion of CB (366 Nm^3CH4 tOM-1). The methane content in the biogas represented 55%. Estimating the energy production data from cassava processing waste for the state of Paraná and its 42 starch factories, the Brazilian state presents a potential for energy utilization of this solid waste of 1,229,760 Nm^3CH4 per day.

METHANE GENERATION FROM CO-DIGESTION OF BANANA, AVOCADO, AND SOYBEAN WASTES

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Agroindustry is an important economic sector linked to the Brazilian trade balance and whose contribution to the national production of biogas has increased. Agroindustrial residues are rich in easily fermented carbohydrates which have the potential to be used as energy sources in anaerobic digestion. Among these residues, those originating from bananas, soybeans, and avocados stand out, as they are produced on a large scale and in different seasons. These residues can be co-digested together due to their nutritional composition: high concentrations of carbohydrates in bananas, protein in soybeans, and lipids in avocados. Co-digestion has benefits such as synergistic effects between microorganisms; increased organic content and higher methane yield per unit of reactor volume. In this context, this study aimed to evaluate the methane potential production from the co-digestion of banana, avocado, and soybean meal wastes. For this purpose, the proportion (w/w) of 50% banana with 25% avocado and 25% soybean meal was tested in biochemical methane potential (BMP) assays. Furthermore, substrates were characterized and the theoretical production of methane for each residue was estimated. Physical-chemical characterizations of the substrates involved analysis of total solids and total volatile solids, pH, humidity, total nitrogen, lipids, and total carbohydrates. The biogas collection for the characterization was performed three times during the experiment, and the composition was analyzed on an Agillent 7890A GC System chromatograph with a thermal conductivity detector (TCD). The values were normalized to standard temperature and pressure and the theoretical production of methane was estimated. Regarding the BMP assays, digestate from a continuous flow anaerobic reactor, pre-degassed for 6 days, was used as inoculum (50gVS L-1) with an inoculum-to-substrate ratio (ISR) established in 4 based on volatile solids contents. Glass flasks were used as reactors and were loaded with the residues in the defined proportion, in addition to the reactors loaded with inoculum only (blanks) for control. The BMP assays were performed in triplicate and operated in batch mode at 40oC with controlled agitation (150 rpm). The results of the BMP test demonstrated that anaerobic co-digestion of banana, avocado, and soybean meal of 50:25:25 proportion presented a methane potential of 410 Nm^3CH4 tMO-1. About residues characterization, results showed 16% of organic matter and 14.3% of carbohydrates in banana, 42.5% of soybean meal protein, and 1.1% of lipids in avocado. From characterization, the theoretical production of methane for each residue was estimated as 324, 347, and 358 Nm^3CH4 tMO-1, respectively. Therefore, it was found that the co-digestion increased methane production by approximately 20% in comparison to the estimated theoretical production for the anaerobic digestion of each waste, allowing greater variation of substrate for microorganisms. Thus, this study demonstrates that the co-digestion of bananas, soybeans, and avocados is advantageous for energy generation in Brazil since they are food wastes with great availability in the country whose nutritional composition collaborates for high methane production.

EVALUATION OF THE USE OF PROTEOLYTIC ENZYME IN THE ANAEROBIC DIGESTION OF NON-SLAUGHTERED SWINE CARCASSES

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The generation of waste in swine production is an inevitable consequence of the process. The destination and treatment of this waste must be sustainable and economically viable. In addition to manure, a large amount of routine mortality waste is generated. Anaerobic digestion (AD) is a well-known process and can be used to treat these organic wastes, as swine carcasses have a high potential for biofuel production. In this sense, this study investigated the degradation of previously comminuted swine carcasses using a proteolytic enzyme (Alcalase - Novozymes 2.4 AU g-1) during AD. The enzyme was tested both as a pre-treatment of the carcasses and in batch AD, in reactors of 1 L, at temperature of 37 °C, with automatic stirring and in triplicate (batch fermentation system - RITTER). Four different AD tests were performed: carcass only, carcass plus alcalase enzyme, pre-hydrolyzed carcass, and inoculum only as control. The same conditions were applied to replicate batch assays in a shaker incubator using 200 mL erlenmeyer jars in which destructive sampling for volatile fatty acid (VFA) determination was performed, following the same ratios and inoculum/substrate ratios. Pre-hydrolysis was performed in a 1/1 ratio of water and pork carcass using an enzyme concentration of 5 ml enzyme kgcarcass-1 in the shaking incubator at 37 °C for 24 hours. Experimental responses were related to biochemical biogas potential (BBP), pH, total organic carbon (TOC), total concentration of VFA, and total ammonium nitrogen (TAN). The pretreatment experiments of the carcasses treated with enzymes showed good results in terms of TOC and TAN dissolved in the hydrolyzed material, namely 81.7% and 102.2%, respectively, compared to hydrolysis without enzymes. The BBP of the carcass after pretreatment with enzymes was similar to that of the carcass without pretreatment, namely 1081 ± 158 mLN gVS-1 and 1109 ± 67 mLN gVS-1, respectively. The test with the carcass and the addition of enzymes in AD was the one that gave the best result with a BBP of 1337 ± 129 mLN gVS-1. In the analysis of VFA, it was possible to identify the behavior of the mediators during the tests. Only in the test with addition of the enzyme in AD, a considerable amount of VFA was present after 24, 48 and 96 hours, at concentrations of 1414, 2806 and 1198 mg L-1, mainly acetic acid (93.5%, 90.9% and 60.4%, respectively). Nevertheless, this does not seem to have negatively affected the tests. Although hydrolysis parameters can still be optimized, pretreatment with enzymes was similar to raw carcass in terms of BBP. However, the use of enzymes during AD of carcasses showed an increase in BBP of about 20%. Pretreatment of swine carcasses with enzymes produces a liquid material that facilitates handling and storage of the swine. The use of proteolytic enzymes can contribute to AD residues with high protein concentrations.

EVALUATION OF MILK WHEY IN THE BIOCHEMICAL METHANE POTENTIAL

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Milk whey is a by-product of the dairy industry, representing about 80 to 90% of the milk volume used in cheese production. The whey consists mainly of soluble proteins, lactose, vitamins, minerals, and a small portion of fat. Thus, its high organic matter content indicates that it can be used as a substrate for biogas production. The use of the biotechnological process for whey treatment brings together advantages concerning the reduction of the organic load of the effluents and the valorization of this by-product, through the production of energy. The reduction of the organic load also reduces the treatment costs and the management of the process residues in a sustainable way. In this context, the biochemical methane potential is a procedure to technically evaluate the properties and parameters involved in the anaerobic digestion process, as well as the potential of a residue to be converted into biogas. Thus, the objective of this work was to evaluate the biogas production and methane yield using milk whey as substrate. The biochemical methane potential was performed according to the specifications and criteria determined by the VDI 4630 standard (2016). Briefly, amber glass bottles of 250 mL were used as reactors, with 30% headspace, and two substrate/inoculum ratios (0.5 and 0.25). The substrate/inoculum ratios were determined from the concentration of volatile solids (VS) and each reactor condition was performed in quadruplicate. The biochemical methane potential test was also performed using only inoculum as a negative control and flasks containing microcrystalline cellulose as a positive control. A volume condition of 140 mL of inoculum was established, whose volatile solids concentration was 9.49 g.L-1. The biogas production was measured using the volumetric method and the biogas volume was corrected for normal temperature and pressure conditions. Moreover, the gas composition was determined on a gas chromatograph. The physicochemical characterization of the substrate showed a pH of 4.2, total solids of 11.40 g.L-1 ± 0.32, and a volatile solid of 7.62 g.L-1 ± 0.30. Thus, the characterization results confirm the slightly acidic nature of whey and the high content of organic matter. The biochemical methane potential test was accomplished for 40 days and the average value of accumulated biogas production was 891.89 ± 21.56 and 990.75 ± 34.89 mLN.gSV-1, for the ratio of 0.5 and 0.25, respectively. The results obtained for both concentrations showed similar behavior, with slow production until the 5th day, exponential growth from the 5th to the 20th day of digestion, and stability in the biogas production process from the 20th day. Regarding the methane yield, the substrate/inoculum ratio of 0.50 obtained an average value of 480.66 ± 20.83 mLN.gVS-1, and the 0.25 ratio presented an average production of 451.35 ± 21.78 mLN.gVS-1. Therefore, the results of the present study demonstrate that whey is a potential substrate for biogas production, since it has a high content of organic matter, and in the two ratios evaluated, methane was detected, indicating that this substrate can be used as an energy source.

BIOETHANOL PRODUCTION FROM RAW ORANGE INDUSTRIAL WASTE USING SEAWATER-BASED FERMENTATION MEDIA

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Citrus fruits, predominantly represented by oranges, are among the most produced and consumed crops globally, constituting a vital processing sector. After processing and extraction of the fruit juice, the residues generated (peel, internal tissues or bagasse, and seeds) are rich in soluble, fermentable sugars, lignin, proteins, essential oils, and polysaccharides such as pectin, cellulose, and hemicellulose. These characteristics make orange residue an ideal source for producing and recovering different individual compounds, such as ethanol, which can be produced from soluble sugars or by subjecting the residue to a treatment step for disintegrating polysaccharides into simple sugars for further fermentation. Given this, this study aims to critically evaluate the challenges of applying industrial orange waste directly, i.e., without removing interfering compounds such as essential oils and galacturonic acid, resulting from the solubilization of pectin, for ethanol production by the yeast Wickerhamomyces sp. UFFS-CE-3.1.2 uses seawater and ultrapure water as a solvent.

The orange residue was suspended in seawater and ultrapure water to solubilize free sugars and treated with sulfuric acid diluted in seawater to release available sugars in the lignocellulosic and pectin fraction. The acid treatment was evaluated by experimental planning (DCCR 2^3), and the influence of the variables acid concentration, solid-liquid ratio, and temperature on sugar release was studied. 8.35±0.10 g L-1 of free sugars were extracted from orange residues, producing ethanol production of 0.61±0.11 g L-1 and 0.57±0.08 g L-1 using seawater and ultrapure water, respectively. The broth resulting from the acid treatment showed high amounts of sugars (51.61±3.67g L-1), including 13.02±1.04 g L-1 of galacturonic acid, but they were not fermented. The presence of essential oils and galacturonic acid in the fermentation broths in citrus residues hydrolysates is a challenge to overcome to enable the direct application of these residues in ethanol production since these compounds can inhibit cellular functions and consequently negatively affect the fermentation process.

ASSESSING OPERATING PARAMETERS FOR USING FRUIT AND VEGETABLE WASTE TO IMPROVE HYDROGEN GENERATION THROUGH DARK FERMENTATION

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Fruit and vegetable waste (FVW) are sugar-rich substrates that can be used to produce hydrogen through dark fermentation. The success of dark fermentation depends on some key operational parameters, which vary based on the characteristics of the substrate. This study aimed to find out how FVW from a large waste producer (a central horticultural wholesaler) should be fermented to produce the maximum amount of hydrogen. The following particular goals were listed: i) determine the pre-treatment method for brewery sludge as inoculum; ii) adapt the mesophilic inoculum to the high temperature conditions; iii) evaluate the dark fermentation of shredded FVW in a low-rate reactor (CSTR); iv) evaluate the fermentation of the liquid fraction of FVW, after the pressing process, in a high-rate anaerobic structured bed reactor (AnSTBR). The innovative operation of the AnSTBR for the dark fermentation of FVW started with sucrose as substrate at a hydraulic retention time (HRT) of 6 h. Then, the sucrose was gradually replaced by FVW at the HRT of 6 h. The FVW was fed as the sole carbon source (5 g COD/L) at HRTs of 6 h, 12 h, and 3 h for at least 20 days on each condition. The heat treatment of sludge resulted in the highest cumulative hydrogen production (90 mL H2). Then, the thermally pretreated inoculum was used to adapt the mesophilic sludge to high temperature conditions. The gradual increase in temperature from 35 °C to 45 °C (2 °C per week) with heat-treated sludge led to the highest hydrogen yield at 43 °C (10.4 mmol H2/g COD), followed by its reduction to 1.5 mmol H2/g COD at 45 °C. In the low-rate reactor (43 °C), a carbohydrate conversion of 45% and the generation of 2.1 g acetate/L were observed. However, no hydrogen production was detected on the biogas of the low-rate reactor. In contrast, the fermentation of the liquid phase of FVW in a high-rate reactor resulted in high efficiencies of carbohydrate conversions. The highest values of hydrogen production rate were observed for FVW as sole carbon source at 6 h (2094 L H2/m3 reactor.d). The attempt to decrease the hydraulic retention time to 3 h caused a reduction in the hydrogen production rate to 216 L H2/m3 reactor.d. It is highly encouraging the increase of the organic loading rate, aiming to reduce the size of the reactor and water expended on dilution, by increasing substrate concentration in future studies.

IS THE CONTINUOUS STIRRED TANK REACTOR APPROPRIATE FOR DIGESTING FRUIT AND VEGETABLE WASTE?

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The high solids content and carbohydrate-rich composition of fruit and vegetable waste (FVW) favor excessive acidification in the anaerobic digestion of this waste, impairing the reactor's stability and methane production. The two-stage anaerobic digestion process stands out among the alternatives to minimize this problem. This study aims to evaluate the single and two-stage anaerobic digestion of FVW applying a continuous stirred tank reactor (CSTR) and compare the performance of both systems. The methanogenic single-stage CSTR (SS-CSTR) was evaluated at organic loading rates (OLR) of 1.0, 1.5, and 2.0 kgCOD.m-3.d-1 decreasing the hydraulic retention time (HRT) from 34 to 22 and 16 d. In the Two-Stage CSTR (TS-CSTR), the first stage, acidogenic (CSTR-1), was maintained with HRT of 2 d and OLR 15 kgCOD.m-3.d-1. The CSTR-1 effluent was fed to the second stage, methanogenic (CSTR-2), whose HRT was 20 and 12 d and OLR 1.5 and 2.5 kgCOD.m-3.d-1, respectively. The best performance was observed in the TS-CSTR system, in which the COD removed of CSTR-2 was 84%, and methane yield (MY) and methane production rate (MPR) of 428 mL CH4.gVS-1add and 0.459 L CH4.Lreactor-1.d-1 were verified. Comparing the single- and two-stage system performance, it is identified that TS-CSTR can promote a reduction of 35 % in the total reactor volume used in the process since the total HRT of CSTR-1 + CSTR-2 was 22 d, and the ST-CSTR showed better performance at HRT of 34 d (MY 312 mL CH4.gVS-1add and MPR 0.339 L CH4.Lreactor-1.d-1). Moreover, the TS-CSTR showed better operational performance and stability, operated at OLR 50% higher that the SS-CSTR and generating 214 kJ.d-1 in its best condition. However, due to the high production of FVW, higher OLR would be necessary for the proper methanization of this residue. In this sense, a pre-treatment of the FVW may be considered, such as centrifugation and/or pressing, generating two streams: one with high solid content and a liquid fraction. the anaerobic digestion of the solid fraction (FVWS) and liquid fraction (FVWL) of FVW was evaluated in batch assays to subsequently apply to the process high-rate reactors and minimize reactors volume. Batch tests were performed with 2.5 gCOD.L-1 at a temperature of 35 °C. The separation of liquid and solid fractions proved to be a reasonable strategy since the maximum biomethane production potential (M0) for FVWL (312 mL CH4.gCOD-1) was higher than for FVW (297 mL CH4.gCOD-1), the latter being equal to M0 for FVWS. Thus, despite the biogas production presented in this study, the CSTR may not be the most appropriate reactor for anaerobic digestion due to the low OLR possible to be employed, having as an alternative the anaerobic digestion of FVWL and FVWS in high-rate reactors.

HYDROGEN AND METHANE PRODUCTION IN TWO-STAGE UPFLOW ANAEROBIC SLUDGE BLANKET REACTORS FROM CRUDE GLYCEROL

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Crude glycerol (CG) is a by-product from biodiesel manufacture and presents about 20% impurities, which limits its industrial application. Although many impurities, such as methanol, soap, catalysts, salts, and non-glycerol organic matter, are potentially toxic to microorganisms, CG has been widely applied as a substrate in anaerobic digestion for obtaining value-added metabolites, as hydrogen, 1,3-propanediol, or methane, separately. However, to date, CG has not yet tested for sequential production of hydrogen and methane using high-rate reactors. Therefore, the aim of this study was to determine the operational conditions, such as hydraulic retention time and substrate concentration on H2 and CH4 production in two distinct upflow anaerobic sludge blanket reactors (UASB). The 13 L H2-producing UASB (UASB-H2) was filled with pieces of corrugated PVC pipe as material support (specific area of 907 m2/m3), inoculated with a methanogenic sludge withdrawn from a brewery UASB reactor, and fed with CG. To inhibit the activity of the methanogenic archaea, chloroform (0.05% v/v) was added to the UASB-H2 influent. The 15 L methanogenic UASB (UASB-CH4) was also inoculated with the same anaerobic sludge, and fed with the UASB-H2 effluent. During the entire operation of the UASB-H2, the CH4 in the biogas was not detected. Despite this, the maximum yield of H2 (YH2) obtained with commercial glycerol was only 0.13 ± 0.05 mol H2/mol glycerol (13% of the maximum theoretical yield) and applying a maximum OLR of 50 kgCOD/m³.d. The soluble metabolites detected in the UASB-H2 effluent showed that 1,3-propanediol was the main metabolite formed during the operation (1.8 to 3.7 g/L). This result is consistent with the observed hydrogen yield since the hydrogen and 1,3-propanediol production branches compete. Surprisingly, it was possible to detect caproic acid at 1.7 g/L in the effluent from the UASB-H2 operated at 9.0 kgCOD/m³.d, suggesting that there was a carbon chain elongation reaction (reverse ß-oxidation). The UASB-CH4 was operated stably with a maximum OLR of 19 kgCOD/m3.d, removing 94% of organic matter and producing 92 L of biogas per day (74% of which was composed of CH4). The ecological succession analysis of the UASB-H2 showed the bacterial population parameters increase at average OLRs, promoting the dominance of generalist species due to a higher carrying capacity from a less specific substrate, increasing system stability due to niche diversification. On the other hand, higher functional organization indicates community specialization making the substrate degradation more efficient. However, it also induces lower stability and resilience to environmental changes due the limited genetic pool available.

POTENTIAL FOR BENCH-SCALE BIOGAS PRODUCTION FROM FLOATED WASTE FROM SWINE SLAUGHTER AND PROCESSING

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Waste generation in the agroindustry is a growing environmental problem, and alternatives for the destination of this waste have been widely studied. In this view, the energetic utilization of flotated sludge, which originated in the effluent treatment stage of pig slaughterhouses, emerges as an option to add value to the waste because, due to the composition rich in lipids and volatile solids, it can use as a substrate for anaerobic digestion and biogas production. In this scenario, flotate samples from two industries (company 1 and company 2) were characterized for their biogas generation potential. Afterward, five bench-scale stirred anaerobic reactor (CSTR) start-up experiments were evaluated and fed with flotate to reproduce operational conditions applicable at full scale. The two flotate samples showed good potential for biogas production (PBB), with the highest PBB found for sample from company 2, which obtained 1,110 ± 154 NmL of biogas/gSVad and 65% methane. The results show the potentiality, considering that the percentage of methane was higher than 65%. For company 1, the PBB was 565 ± 98 NmL of biogas/gSVad and 73% of methane. The reactor start-up experiments showed that it is necessary to heat the reactor biomass and use inoculum since the substrate used has been shown to have low buffering capacity. Over time, system failures may occur, as an increase in the AI/AP ratio and decrease in pH was observed, as well as an accumulation of Volatile Fatty Acids over the time of the experiment. An increase in the intermediate alkalinity/partial alkalinity (IA/PA) ratio of 1.59 mgHac./mgCaCO3 was observed in Experiment 5, with acetic acid accumulation after increasing the organic loading rate (OLR). The recommended OLR for this substrate type in CSTR-type reactors is 1.0 - 1.3 SVkg./m3reator. In addition, it is emphasized that the use of alkalinity supplementation by co-digestion with pig manure presents itself as an efficient alternative for the recovery of overloaded reactors.

STUDY OF NEURAL MODELS FOR OPTIMIZATION OF BIOGAS PRODUCTION

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Waste management plays a significant role and a big challenge due to the rise of agriculture and livestock in Brazil. In most cases, the simple disposal of the wastes is not a good practice as they usually have a great potential for energy production. Anaerobic digestion is a process that can be employed to produce biogas and bioenergy from a great variety of feedstocks, mainly because of the type of technology used to biodigest the substrate. The reactions involved in fermentation and metagenesis depend on the synergy between the microorganisms and the process conditions, such as pH, temperature, applied organic load and adequate inoculation. Many studies related to biogas production can be better understood when modeling and simulation tools are used. The interest in using artificial intelligence for modelling the anaerobic biodigestion process has notably increased in recent years. A model representing the reactions in anaerobic biodigestion can be considered a 'black box'. In this sense, neural networks is presented as an attractive tool for analyzing this kind of process that may be difficult to be represented by a phenomenological model. Considering the applicability of ANN models for the anaerobic biodigestion process, this study evaluated the use of neural models to predict biogas produced some period ahead, using the relation between operational conditions and biogas volume produced (BVP). Three lab-scale biodigesters operated for 55 days. Data from pH, FOS/TAC ratio and BVP were collected throughout the experiment to feed the artificial neural network (ANN) and Adaptive Neuro-Fuzzy Inference System (ANFIS). In addition to the experimental conditions, the models used the BVP produced in the present state and 24 h before to predict the BVP 24 h in advance. The ANN and ANFIS models were developed using Matlab 2019b changing the activation functions, the number of neurons in the hidden layers and training algorithms in the case of ANN and range of influence and squash factor for ANFIS models. The experimental results showed that all the biodigesters operated within the recommended pH range. The monitoring of the FOS/TAC and BVP indicated that despite the similar conditions of feeding and temperature, the biodigester equipment's differences affected the performance of the process. The modelling strategies adopted to predict the BVP 24 h ahead showed promising results, with high R2 values (0.948 for ANN and 0.961 for ANFIS) and low SSE values of 15.69 (ANN) and 9.89 (ANFIS). The models developed may be an interesting tool to correct disturbances in the anaerobic biodigestion process and optimize biogas production.

VFA ACCUMULATION IN THE CO-DIGESTION OF FLOATED SLUDGE AND ACTIVATED SLUDGE FROM THE TREATMENT OF EFFLUENTS FROM THE SLAUGHTERING AND MEAT PROCESSING INDUSTRY

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This study aimed to monitor the organic acids generated and the performance in methane production in a CSTR reactor in the co-digestion of different proportions of waste from floated sludge (LF) together with activated sludge (AL), both waste generated in large volumes in the meat slaughtering and processing industry. A CSTR reactor with a useful volume of 14 L was used, operating with semi-continuous feeding, agitation (100 rpm), TDH of 20 d and Tº35ºC. The mean operating period for each treatment was 41 d. The residues were collected in a poultry and fish slaughter and processing industry, located in the western region of the state of Paraná, Brazil, and were stored in a freezer. The proportions of 70%LF+30%LA with OLR of 0.39 gSVadic.L-1.d-1 (T1) and 1.72 gSVadic.L-1.d-1 (T2) and the proportion of 90%LF+10%LA, with OLR of 0.54 gSVadic.L-1.d-1 (T3) and 1.53 gSVadic.L-1.d-1 (T4). The reactor was inoculated with sludge from an anaerobic reactor of a whey plant, and the results of the reactor start-up period were not detailed in this article. The following parameters were monitored: Total alkalinity and volatile acidity (Ripley et al;1986), soluble COD (APHA,2012) and volatile organic acids (Penteado et al.;2013). The volume of biogas was determined by moving the gasometer, and the gas composition was determined using a gas chromatograph. The response variables were: AI/AP ratio, volatile fatty acids (VFA), soluble COD removal (COD) and methane yield (MY). The results obtained for the AI/AP ratio were 0.27 (T1), 0.18 (T2), 0.28 (T3), and 0.31 (T4), demonstrating stability in all assays. The VFA averages obtained were 126.5 mg.L-1 (T1), 148.7 mg.L-1 (T2), 3028.4 mg.L-1 (T3), and 4459.8 mg.L -1 (T4). For COD removal, the mean values obtained were 67.55% (T1), 57.82% (T2), 52.34% (T3), and 51.11% (T4). With the increase in OLR from 0.39 to 1.72 gSVadic.L-1.d-1, between treatments T1 and T3, resulted in MY (as a function of added SV) of 293.30 mLCH4 g-1 SV for T1, and 310.30 mLCH4 g-1 SV for T3. While in the proportion of 90%LF+10%LA, the increase in OLR from 0.54 to 1.53 gVSadic.L-1.d-1, between treatments T2 and T4, resulted in MY of 240.03 mLCH4 g -1 VS for T3 and 388.74 mLCH4 g-1 SV for T4. It is therefore concluded that with the increase in organic load as a function of the increase in the content of floated sludge in co-digestion, the results obtained for T4 (90%LF+10%LA with OLR 1.53 gSVadic.L-1.d- 1) showed the best methane yield (388.74 mLCH4 g-1 VS). However, with the increase in the floated sludge content in conjunction with the increase in load, it contributed to a decrease in the efficiency of COD removal, with an increase in the accumulation of VFA, with emphasis on propionic and butyric acids, and these acids can cause the inhibition of methanogenic microorganisms.

INFLUENCE OF INCREASED OLR ON THE CO-DIGESTION OF SLUDGE RESIDUES FROM THE SLAUGHTERING AND MEAT PROCESSING INDUSTRY

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This study aimed to evaluate the influence of increased organic load on the co-digestion of floated sludge (LF) waste together with activated sludge (AL), both waste generated in large volumes in the slaughtering and meat processing industry. A CSTR reactor with a useful volume of 14 L was used, operating with semi-continuous feeding, agitation (100 rpm), TDH of 20 d and Tº35ºC. The mean operating period for each treatment was 41 d. The residues were collected in a poultry and fish slaughter and processing industry, located in the western region of the state of Paraná, Brazil, and were stored in a freezer. The proportions of 70%LF+30%LA with OLR of 0.39 gSVadic.L-1.d-1 (T1) and 1.72 gSVadic.L-1.d-1 (T2) and the proportion of 90%LF+10%LA, with VOC of 0.54 gSVadic.L-1.d-1 (T3) and 1.53 gSVadic.L-1.d-1 (T4). The reactor was inoculated with sludge from an anaerobic reactor of a whey plant, and the results of the start-up period and load adaptation of the reactor were not detailed in this article. The monitoring of the reactor was carried out based on the determination of the parameters: SV (APHA, 2012), OG (Suehara, 2005) and volatile organic acids (Penteado et al.; 2013). The volume of biogas was determined by displacing the gasometer, and the gas composition was determined using an Agilent Technologies 7890B gas chromatograph with a TCD detector using argon as the carrier gas. The response variables were: methane yield (MY), volatile solids removal (VS) and oil and grease removal (OG). The results obtained for the removal of VS were 70.85% (T1), 79.04%(T2), 80.51(T3)% and 72.59%(T4). For OG, the removal results were 62.05% (T1), 60.46% (T2), 65.41% (T3) and 71.11% (T4). With the increase in OLR from 0.39 to 1.72 gVSadic.L-1.d-1, between treatments T1 and T3, resulted in MY (as a function of added SV) of 293.30 mLCH4 g-1 SV for T1, and 310.30 mLCH4 g-1 SV for T3. While in the proportion of 90%LF+10%LA, the increase in OLR from 0.54 to 1.53 gVSadic.L-1.d-1, between treatments T2 and T4, resulted in MY of 240.03 mLCH4 g -1 VS for T3 and 388.74 mLCH4 g-1 VS for T4. The obtained methane content was 52.66%(T1), 56.23%(T2), 60.72%(T3), 61.46%(T4). It is concluded that with the increase in organic load due to the increase in the content of floated sludge in co-digestion, the results obtained for T4 (90%LF+10%LA with OLR 1.53 gVSadic.L-1.d-1) showed the best methane yield per amount of volatile solids added to the reactor (388.74 mLCH4 g-1 VS), and this treatment also showed the highest methane content (61.46%), and the best removal for GO (71.11%).

BIOHYDROGEN PRODUCTION FROM FERMENTED CASSAVA STARCH WASTEWATER

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In readily fermentable agro-industrial wastes, such as cassava starch wastewater (CSW), low yields and instability in hydrogen production have been associated with lactic acid bacteria (LAB). These microorganisms, naturally present in the residue, can compete for substrate or cause the detour of metabolic pathways. To circumvent this bottleneck, the conversion of the substrate to lactic acid (LA), in a step before dark fermentation (DF), has been quoted as a promising solution, considering that this metabolite can be used as a carbon source by hydrogen-producing bacteria (HPB) minimizing losses in hydrogen production due to the presence of LAB and other competitors. Thus, this study aimed to evaluate the fermentative production of lactic acid through the anaerobic codigestion of CSW and glycerol and its use as a potential substrate for hydrogen production via DF. Lactic acid production was evaluated using a central composite rotational design, whose independent variables were pH (5.0, 5.15, 5.5, 5.85, and 6.0) and glycerol content added to CSW (0, 0.5, 1.75, 3.0 and 3.5%). The 11 trials, with three replicates of the central point, were conducted in a shaker at 36 °C for 72 h. The inoculum was obtained from natural fermentation of CSW (48 h, 30 °C), and the initial substrate concentration was set at 20 gCOD/L. In the subsequent step (phase 2), the reaction medium from each of the 11 trials was used as substrate to evaluate hydrogen production. The trials (11 flasks) were inoculated with thermally treated anaerobic sludge (100 °C, 15 min), and the initial pH was adjusted to 6.0. The flasks were incubated in a shaker at 36 °C for 14 days. LA production was the only statistically significant response variable among those analyzed. The regression indicates that the AL concentration decreases with increasing glycerol content while the optimum pH is at 5.5. Co-digestion of CSW and glycerol resulted in LA concentrations ranging from 0.9 to 6.2 gCODeq, with yields between 0.02 and 0.34 gCODeq/gCODapllied, with the highest production and yield obtained under the same experimental conditions (pH 5.5 and 0% glycerol). In the second phase of the experiment, the variables pH and glycerol content exerted a significant effect on cumulative H2 production and yield, whose best performance (99. 2 mLH2 and 5.5 mmolH2/gCarb) was obtained under distinct conditions of pH (5.5 and 5.15) and added glycerol content (1.75 and 3.0%), respectively. The variable carbohydrate conversion efficiency ($p>0.05$) did not influence hydrogen production, indicating possible changes in metabolic pathways. This dynamic can be observed from the metabolite profile, whose concomitant decrease in the concentration of lactic (91%) and acetic (73%) acids indicates their conversion into butyric acid and hydrogen. At the concentrations evaluated the addition of glycerol to CSW did not positively influence LA production. Despite the high concentrations of carbohydrates in the medium, there was significant consumption of AL, indicating that conversion of the residue to a common intermediate may be a strategy to select HPB and contributes to minimizing competition for substrate and the presence of hydrogen consumers.

EVALUATION OF CELLULASE ENZYME IN ANAEROBIC DIGESTION OF AVIAN WASTE

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Poultry litter is the material used to cover the floor of poultry houses on farms. It is mainly composed of sawdust, wood shavings, rice straw, along with urine, feces, and leftover feed. Improper disposal of poultry waste causes environmental impacts, such as greenhouse gas emissions, excessive mineral content in the soil, and contamination of groundwater. With a projected 30% increase in poultry production by 2028, one of the concerns for the sector's growth is the management of these residues. One alternative for the utilization of poultry litter is anaerobic digestion (AD), where the substrate is transformed through microbial decomposition into compounds with high energy content like methane gas. However, poultry litter contains a large amount of lignocellulosic materials that are difficult to decompose, requiring pre-treatment methods. Thus, the objective of this study was to evaluate the enzymatic pre-treatment with cellulase in the poultry litter for the anaerobic digestion process. Experiments were conducted in 500 mL bottles containing 10% (V/V) swine inoculum, 25.5 g VS/L (volatile solids) of poultry litter, and 2% cellulase enzyme, with the control assay conducted without the addition of the enzyme. To activate the enzyme, the reactors containing the substrate were kept in a water bath for 18 hours at 55ºC and pH 5.5. For the methanogenic process, the pH was adjusted to 7.5, and the bottles were kept agitated at 37ºC. The results showed a reduction in the lag phase and an acceleration in methane generation in the assays containing cellulase. After 20 days of anaerobic digestion, we observed methane production of 1272 mL, representing a 13% increase compared to the control (1120 mL). Cellulase enzymes efficiently assisted in the hydrolytic process of poultry litter, accelerating methane production and enhancing the substrate's utilization by microbial metabolism. Although economic feasibility studies are still necessary, the results showed that enzymatic treatment is a strategy to improve waste conversion for renewable energy production, reduce environmental impacts, and contribute to the sustainability of the poultry sector.

BIOCHAR PRODUCED FROM SEWAGE SLUDGE

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The production of waste has generated new challenges for society due to the high quantities produced in large population centers. The sludge generated by sewage treatment plants represents in volume only 2% of the treated effluent, although the cost of its handling can reach up to 60% of the total spent in the process. The worldwide production of sludge from residential and industrial water treatment is approximately 23.0 million tons of dry matter per year. Of this amount, about 40% is placed in landfills and another 27% of this material is incinerated. The generation of this waste in Brazil is approximately 370,000 tons per year. The main destinations of this waste are landfills, incineration or land application. Due to the presence of some toxic components, soil application restricts its use for agriculture. In addition, disposal in landfills ends up generating leachate, in addition to being an environmental liability. Thus, alternatives are wanted for an adequate use of this sludge, one of them being the thermochemical process of pyrolysis. Pyrolysis has three products, non-condensable gas, which can be reused in the system to generate energy / heat, oil with energy potential, in addition to a carbonaceous solid (char), having functionalities such as soil improver, adsorbent, fuel among other applications. The pyrolysis process has potential in the treatment of sludge, as it reduces the volume of waste, in addition to generating products with added value. This study aims to verify the potential of biochar produced by sewage sludge in pyrolysis. The sludge used in this work came from the city of Cachoeira do Sul, characterized by immediate analysis and thermogravimetric analysis, which presented high moisture content (59.04%) and high ash content on a dry basis of 46.94%. The thermogravimetric analysis can observe the excess moisture in the material, in addition to showing a volatile matter content (20%) close to that obtained in the immediate analysis. Pyrolysis was carried out with a heating rate of 5 °C/min at three different temperatures (300, 400 and 500°C) with a residence time of 1 hour, the biochar yield was 56.21%, 58.88% and 59.64% at each of the analyzed temperatures. The oil concentration increased with increasing temperature in the process, while the gas content decreased at 400 °C and 500 °C compared to pyrolysis at 300 °C. The biochar ashes were higher than the sludge as expected, in the pyrolysis at 500 °C the biochar presented the highest ash content of 60.24 % among the samples. The study showed that the sludge needs pretreatment to produce a biochar with lower ash concentration, this high ash content in the material makes it difficult to use biochar in applications such as adsorbent or energy source. Due to this, the continuation of the research will be to look for methodologies to reduce the ash present in the sewage sludge.

TECHNOLOGIES FOR WASTE TRANSFORMATION, REUSE AND DISPOSAL

POTENTIAL USE OF RESIDUAL DIATOMACEOUS EARTH AS BIOSORBENT IN THE ADSORPTION OF CADMIUM

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Waste from agro-industrial activities, which are not reused within the enterprises themselves, are emerging as promising alternative sources for the decontamination of aqueous media containing toxic elements, in the form of biosorbents. The Biosorption stands out as a simple, and low-cost, method of adsorbing different contaminants using waste from different sources as a biosorbent medium. The present study aimed to evaluate the reuse potential of residual diatomaceous earth (RDE), obtained from the beer filtration/clarification step, in the Cadmium adsorption process. The evaluation of the reuse potential of diatomaceous earth was made through the selection of the isotherm model that best described the Cd adsorption process. RDE was chemically characterized by Point of Zero Charge (pHPCZ) and Fourier-Transform Infrared Spectroscopy (FTIR). The adsorption assay was carried out through laboratory adaptation of the Batch Method, with ascending concentrations (0, 38, 46, 58, 82, 130 and 288 mg L-1) of CdCl2. Then, seeking to determine the type of adsorption established between residue and metal, an adsorption test was performed by adding KCL 1 mol L-1 solution to the residue remaining from the previous process. As it has a pH of 10,28, this was corrected until the solution reached a range between 5,7 and 6,2, considered optimal for better process efficiency. Therefore, the parameters of the adsorption isotherms were determined using the IsoFit program. The comparison of isothermal models was performed using the determination coefficient (R2), corrected Akaike Information Criterion (AICc) and Akaike variation (?AICc). The results showed that the Freundlich model best described the Cd sorption. The adsorption occurred in a specific way, in complexes with an internal sphere, the result of which can be attributed to the negative electrical charges present on the surface of the residue and to the silicate functional groups and hydroxyls, thus promoting greater efficiency in the adsorptive process, because the more negatively charged is the surface of the biosorbent, the higher the concentration of adsorbed metal ions. RDE can be reused as a sustainable technology for removing Cd from aqueous solutions. In addition to behaving as an excellent biosorbent, it has the advantages of being a low-cost material and also being able to be reused in its “raw” form, without the need to undergo a previous treatment, which facilitates its reuse both in the industry and in rural properties aiming at the treatment of effluents.

EVALUATION OF COPPER ADSORPTION POTENTIAL USING MALT BAGASSE

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Despite the socioeconomic importance that the agro-industrial sector has for the country, this activity generates large amounts of organic waste, reaching the amount of 967 thousand ton/year in 2022, which, without proper treatment and disposal, are seen as sources of contamination and, in view of the importance of the circular economy, studies on the reuse of these residual biomasses have been gaining more expressiveness in recent years. Thus, one of the forms of use would be as low-cost biosorbents in the removal of pollutants present in aqueous media. The present study aimed to evaluate the potential for reuse of malt bagasse (MB) in the copper adsorption process. The evaluation of the malt bagasse reuse potential was carried out by selecting the isotherm model that best described the Cu adsorption process. Surface charges and functional groups of MB were determined, respectively, by Point of Zero Charge (pHPCZ) and Fourier-Transform Infrared Spectroscopy (FTIR). The adsorption test was carried out through laboratory adaptation of the Batch Method, with ascending concentrations (0, 30, 60, 120, 200, 280 and 360 mg L-1) of CuCl2. Next, in order to determine the type of adsorption established between waste and metal, a desorption test was carried out by adding KCl 1 mol L-1 solution to the remaining waste from the previous process. As it has a pH value of 7,18, this was corrected until the solution reached a range between 5,4 and 6,2, considered optimal for better process efficiency. Therefore, the parameters of the adsorption isotherms were determined using the IsoFit program. The comparison of isothermal models was performed using the determination coefficient (R2), corrected Akaike Information Criterion (AICc) and Akaike variation (?AICc). The results showed that the Langmuir model best described the Cu sorption. The adsorption occurred in a specific way, in complexes of the internal sphere, whose result can be attributed to the negative electrical charges present on the surface of the residue and to the functional groups carbonyl and carboxylic and aromatic carbons that are related to the presence of lignocellulosic compounds (lignin, cellulose and hemicellulose) that make up the malt, thus promoting greater efficiency in the sorption process. In general, malt bagasse proved to be a biosorbent with great potential for use in the removal of Cu in aqueous solutions.

MOTIVATIONS AND BARRIERS TO INVEST IN BIOGAS PROJECTS BY SWINE PRODUCERS ACROSS SOUTHERN BRAZIL

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Increased global demand for pork has prompted a shift in Brazil's agricultural system. To feed this demand, southern Brazil (i.e., Santa Catarina, Parana and Rio Grande do Sul) has responded by raising approximately 20.6 million pork; however, as production grew exponentially, environmental regulations did not. Manure management technologies, such as anaerobic biodigesters, have been diffused to reduce methane emissions, but also, to generate energy and reduce operational costs. Despite past efforts, adoption has remained low. Today, only 202 plants are operating in southern Brazil among a population of 1,386,122 of swine breeders and other livestock owners.

From January 2020 to January 2022 we surveyed 84 swine producers across the southern region ranging in size (500-15,000 head) to investigate motivations and barriers for investing in biogas projects. A biogas project was defined as the installment of an anaerobic digester connected to a generator. Both adopters and potential adopters (i.e., those not having a project) were surveyed evenly across states. Apart from investigating property characteristics among adopters, other topics included project management costs, technical issues, financing, biomass treatment, and biogas use. The topics investigated among potential adopters were similar, including expected cost of biogas projects, availability of finance information, and general benefits/issues heard about projects.

The average cost of projects reported by adopters and average cost potential adopters were willing to pay were relatively similar, being R$ 578,000 and R$ 555,000 (per 2000 animals), respectively. Furthermore, average and minimum payback time (in years) were somewhat analogous between adopters (minimum = 3 | average = 6) and potential adopters (minimum = 3 | average = 7.5). Approximately 50.0% of adopters and potential adopters agreed payback time was largely driven by participation in the net metering system (i.e., renting their generator to an outside party). Differences, however, arose between business plans, where 32.5% and 15.0% of adopters reported income from biogas projects were derived from auto-consumption and heating for animals. On the other hand, 84.1% and 29.5% of potential adopters suggested their income would be come from auto-consumption and heating. Neither adopters (13.9%) nor potential adopters (15.8%) mentioned they could access liquid biofertilizer markets, but more so, they could benefit from solid biofertilizer markets (58.3% vs 67.6%).

More adopters reported that they maintained their biodigesters individually (as opposed requesting specialists), which may be attributed the distance (1-1200 km) between their farm and maintenance personnel. This is disconcerting for potential adopters, as 50.0% reported technical issues as a primary concern preventing investment. More concerningly though, adopters reported a range of finance rates, receiving between 2.8% and 8.5%. In sum, there are numerous motivations and barriers for investing in biogas projects. Financial, environmental and energy regulatory agencies must consider these to support the pork sector with policies that open new financial avenues for biogas adopters, but also reduce environmental externalities from production systems now and in the future.

PARAMETERS EVALUATION FOR HYDRODYNAMICS STUDY IN BIODIGESTERS

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There are several factors that must be taken into consideration for the construction of biodigesters, among them, hydrodynamics, through which it is possible to use mathematical modeling that makes it possible to evaluate the behavior of fluid dynamics and compare different structural configurations. In this context, the objective of this work was to evaluate the appropriate physico and chemical parameters to develop an assertive analysis of the hydrodynamics of a bioreactor. For the experiment, two horizontal anaerobic reactors (build in polypropylene) were used, with a total volume of 32 liters (29 liters useful volume) with inlet at the top and outlet at the bottom (drain), positioned at opposite ends, operating in a piston regime. One of the reactors has a concentric shaft fitted with stirring rods (paddles) continuously driven at 1.6 rpm. The experiment consisted in performing a pulse feeding with a tracer followed by daily feedings of 1.3 L of water (TRH = 22.3 days). Sulfuric acid (1 mol/L), methylene blue (1% w/v) and food coloring were used as markers for the experiment, but these compounds adsorbed in the reactor construction material surface making observations impossible. So, it was decided to use 100 g of poultry litter as a marker, because it has components that sediment, float, and solubilize when mixed in water. The experiment was monitored for 32 days. Reactor effluent samples were collected and analyzed for the following parameters: pH, turbidity, ammoniacal nitrogen (NH3-N), total solids (TS), total organic carbon (TOC) and total nitrogen (TN). The pH values remained between 6.4 and 6.9 throughout the experiment for both reactors, without demonstrating a differentiated profile between treatments, dispensable to achieve the objective of this study. This fact is expected due to buffering effects that may occur in the interaction between the poultry litter and water. The other parameters evaluated showed a difference in profile between the agitated and non-agitated treatments. The non-agitated reactor showed maximum values of turbidity, TS, TOC and TN on the day after the pulse with the poultry litter (first day of operation). However, NH3-N presented maximum concentration at the outlet of the non-stirred reactor during the third day of operation. The stirred reactor showed greater homogeneity in the results, between the first 15 to 20 days of operation, in all parameters analyzed. Finally, the parameters of TS, TOC and TN showed similarity in both treatments, concluding that for analysis of the hydrodynamics of the reactor one can choose to use only one of these.

IMPROVEMENT OF ANAMMOX GRANULE SIZE DISTRIBUTION IN A EGSB REACTOR FED WITH REAL EFFLUENT AT DIFFERENT NITROGEN LOADING RATE

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Biological processes are widely used for the removal of high nutrient loads, especially nitrogen, in wastewater treatment systems. Among these processes, Anammox stands out due to several operational and economic advantages over other technologies.
In this study, anammox granule size distribution was evaluated during reactor operation once sludge granulation is a key issue for success process performance. An EGSB (Expanded Granular Sludge Bed) reactor with a volume of 1L was inoculated with 300 mL of anammox sludge, coming from a pilot reactor operating for 250 days. The reactor was fed with 200 mgN.L-1 of total nitrogen (100 mg L-1 of NH4+-N from a UASB (Upflow Anaerobic Sludge Blanket) reactor fed with swine manure and 100 mg L-1 of NO2--N supplemented with NaNO2 solution). The reactor was operated for 130 days, and the hydraulic retention time (HRT) was adjusted from the feed flow rate (Qin), increasing the nitrogen loading rate (NLR). After reactor efficiency stabilization (NH4+-N and N-NO2--N concentrations below 30 mg.L-1). Reactor samples were collected daily from the influent and effluent. Kinetic tests of substrate consumption were performed at reactor inoculation and after 50 and 130 days of operation to determine the specific activity of bacteria through the consumption rate and the specific rate of substrate consumption (rs, mgNH4+-N.h-1) and (µs, mgNH4+-N.gVSS-1.h-1). All physicochemical determinations were performed according to Standard Methods (APHA, 2022). Sludge particle size distribution analysis was performed using sieves with nominal diameters of 2.4, 1.4, 0.7, 0.3 and 0.2 mm. Qin was gradually increased from 5.7 L.d-1 to 8 L.d-1, reducing the HRT from 4.2 h to 3 h. The range of NLR applied was 0.8 to 1.6 g.L.d-1. The µs data showed a significant improvement between days 0 and 50 of reactor operation, from 1.04 mgNH4+-N.gSSV-1.h-1 to 2.12 mgNH4+-N.gSSV-1.h-1 for ammonia and 1.19 mgNO2-.-N.gSSV-1.h-1 to 2.17 for - mgNO2-.-N.gSSV-1.h-1, respectively, indicating that the strategy of increasing the flow rate was efficient for better distribution of the substrate inside the reactor. The same occurred with the calculation of the stoichiometric coefficients for the two kinetics, from 0.58 for NO2--N on day 0 to 1.21 on day 50, and from 0.04 to 0.15 for NO3--N, respectively. During days 50 to 130, there was a reduction in µs, 1.01 mgNH4+-N.gSSV-1.h-1 and 0.76 mgNO2-.-N.gSSV-1.h-1, respectively; however, the stoichiometric coefficients remained close to those in the literature 1.18 and 0.31, respectively for NO2- and NO3-. The results of volatile suspended solids (VSS) obtained during the experimental period corroborate with the improvement of the granule size distribution inside the reactor. The system was inoculated with a VSS/STS ratio of 67%, and after 130 days achieved 80%. This increase can be related to the change of granules size distribution, which in their majority (57.7%) were smaller than 0.30 mm on day 0 (flocculent characteristic) and became 1.4 mm (57%) after 130 days of operation. It can be concluded that the anammox sludge granulation was improved whith the adopted operational conditions.

DEVELOPMENT OF BIODEGRADABLE FILMS BASED ON WHEY USING CITRIC ACID AS A CROSSLINKER

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Polymeric materials are fundamental in the structuring of products due to their mechanical properties and low cost. However, because many of these polymers are derived from petroleum, a non-renewable raw material, developing biodegradable polymers obtained from renewable sources, which can decompose naturally with the action of microorganisms, are fundamental for the transition to a production system based on sustainability and environmental balance. Within this context, whey, a by-product of the dairy industry, presents itself as an alternative renewable raw material, attributing flexibility without giving color or odor to the material produced. Thus, this study aimed to produce and evaluate films based on whey and gelatin (secondary raw material) using the casting technique. The proposed formulations were composed of distilled water (solvent), glycerol (additive), and chitosan (additive) in equal amounts and citric acid (crosslinker) in different concentrations. The characterization analyses showed that the increase in the concentration of cross-linking agent caused the increase in thickness and the degree of solubility of the films. Only the films produced with 40 wt.% of crosslinker resulted in hydrophilic character in the contact angle test. The tensile strength and elongation at break test elucidated an indirect relationship between Young's modulus and the breaking stress with increasing citric acid content, resulting in an increase in elongation at break, demonstrating the role of citric acid as a plasticizer in the proposed formulation. Morphological analysis revealed that the films produced had dense structures, regardless of composition, in addition to the possible presence of surface crystallization. The FTIR tests of the films revealed the presence of characteristic bands of whey in the fingerprint region and bands referring to gelatin in the other regions, in addition to the directly proportional relationship between the degree of esterification and the percentage of crosslinker. As for the thermal stability, the increase in the citric acid concentration resulted in lower thermal stability, with more intense mass losses and a decrease in the initial decomposition temperature. The glass transition temperatures of the films produced were not influenced by the addition of a crosslinker, regardless of the concentration. Through the analyses, it was noticed that the films made with 10 wt.% and 20 wt.% (relative to whey mass) of citric acid have the potential for future applications as packaging. Thus, studies on films produced from whey and gelatin present promising perspectives in producing and optimizing new formulations for practical application and basic research aimed at developing new formulations and additives to improve the properties and applicability of renewable biopolymers.

ISOLATION AND IDENTIFICATION OF A NITRITE-OXIDIZING STRAIN AS A BIOAUGMENTATION STRATEGY FOR RECOVERING NITRATATION PROCESSES

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Nitrogen is a pollutant present in effluents from sectors such as agribusiness, livestock, and meat-packing plants, which, when not treated or managed correctly, affect the environment and human health. The biological process of nitrification/denitrification is widely employed in wastewater treatment due to its efficiency and operational practicality. In nitrification, ammonium oxidizing bacteria (AOB) oxidize ammonium to nitrite (nitritation), and subsequently, nitrite-oxidizing bacteria (NOB) convert nitrite to nitrate (nitratation). In the absence of oxygen, nitrite (NO2-) and nitrate (NO3-) can be reduced to nitrogen gas by denitrifying bacteria (denitrification). However, challenges such as microbial imbalances, substrate inhibition, competition, and operational limitations (lack of energy, oxygen transfer) can reduce the overall efficiency of the process and impede the rapid recovery of the reactors in full-scale plants. Thus, using bioaugmentation techniques that use specialized cultures from selected microorganisms with a high degradation potential can be a good strategy for restoring the process after shocks. This study aimed to isolate a NOB strain using sludge from a full-scale nitrification/denitrification system treating swine wastewater as inoculum. To favor nitrite-oxidizing strains, an enrichment of the inoculum was performed. The culture enrichment was carried out in a shaker at a controlled temperature (25°C) and agitation (150 rpm). A synthetic medium based on sodium nitrite at different concentrations in duplicate (100, 300, and 1000 mg of NaNO2 L-1) was utilized to feed the system, and the nitrite input and nitrate output were analyzed for process monitoring. The results indicated that swine wastewater treatment systems are promising sources for nitrite-oxidizing bacteria isolation, enabling the isolation of the strain belonging to the genus Nitrobacter. Optimal growth of the Nitrobacter strain was observed at concentrations ranging from 100 to 300 mgNaNO2 L-1, which can be justified by the inhibitory effect promoted by the high concentrations of nitrite in the medium. In this concentration range, the nitrite removal was around 96%, indicating satisfactory process development. Although isolation of bacterial strains related to the nitratation process in a solid medium is not usual, it is a crucial tool for understanding the physiological characteristics of bacteria and their correct application. In conclusion, this study demonstrates the successful isolation of a NOB strain. This isolation offers the selection of better strains, being an essential ally for the bioaugmentation process.

THERMOECONOMIC ANALYSIS OF A RURAL MICRO-GENERATION POWER PLANT INTEGRATED WITH A FERTIGATION SYSTEM

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The segment of biofertilizers stabilized in anaerobic digesters is a promising solution to reduce dependence on imported products. One of the greatest challenges for the development of this sector is the logistics, the cost and feasibility of treatment, transport, and distribution of such organic fertilizers. To contribute to the reduction of these difficulties, this study proposes a thermoeconomic analysis of four scenarios applied in a rural microgeneration power plant, located in Toledo (PR). In the thermodynamic analysis, the potential for electricity generation from swine residues were evaluated. While the economic analysis was determined using the net present value (NPV), internal rate of return (IRR), payback period (PBP), as well as the Levelized Cost of Energy (LCOE) and biofertilizer (LCOB_f). Some results indicated that the energy consumption to fertigate one m^3 of swine manure, under the analyzed fertigation conditions, corresponds to only 2.95% of the potential for electricity generation of this manure, estimated at 13.20 kWh·m^(-3), which would allow the energy self-sufficiency of the system. The economic indicators of the scenarios considered reveal that they are viable, not due to energy self-sufficiency, but due to the sale of all electrical energy and the transport service and sale of the biofertilizer.

PROSPECTING ß-GLUCOSIDASE-SECRETING YEASTS IN FALL ARMYWORM GUTS

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Cellobiose is a disaccharide composed of ß-1,4 bonds between glucose molecules. It is derived from the hydrolysis of cellulose present in agricultural, forestry, and fruit peel residues. Considering that the yeast Saccharomyces cerevisiae (the most widely used species in the first-generation (1G) ethanol production) does not have enzymes capable of cleaving the ß-1,4 bonds mentioned above, it is necessary to look for wild yeasts that carry cellobiases and thus can replace, provide genes or act together with S. cerevisiae to make the second-generation (2G) ethanol production process more viable. ß-glucosidases, the class of enzymes to which cellobiases belong, can be found in the complex of cellulolytic enzymes, which are essential in the cellulose hydrolysis process. They are required for the use of lignocellulosic biomass residues as feedstocks for 2G ethanol production. In this context, the search for yeasts in environments such as the digestive tract of herbivorous insects, as in the case of the fall armyworm (Spodoptera frugiperda larvae), is promising due to their diet based on plant biomass, which leads to a selective pressure over their intestinal microbiota. Therefore, the present work aimed to evaluate 46 yeast strains isolated from the intestine of S. frugiperda larvae. Yeast strains were screened for extracellular ß-glucosidase activity and cellobiose consumption. For the enzymatic assay, supernatants of culture media collected after 48 h of incubation were mixed with a cellobiose solution and kept for 1 h at 30°C and 50°C for subsequent quantification of the glucose released by hydrolysis. Of the 46 strains tested, only four were able to secrete ß-glucosidases outside the cell. The highest activities were observed at 50°C. The strain CHAP-159 stood out, showing a cellobiase activity of 61.92 ± 3.23 U/mL. On the other hand, it was observed that 29 of the 46 strains consumed more than 50% of the cellobiose provided during the 48 h of cell culture, thus indicating that they are capable of metabolizing the disaccharide, even though they do not secrete enzymes out of the cell. In this case, yeasts may have (i) periplasmic cellobiases, which break down cellobiose between the cell wall and plasma membrane, or (ii) cellobiose transporters and intracellular ß-glucosidases, which promote the internalization of the disaccharide and its cytoplasmic hydrolysis. Thus, the prospection suggests that the isolated strains can contribute to the improvement of hydrolysis processes of lignocellulosic residues and, consequently, to the production of second-generation ethanol.

OBTAINING PHENOLIC COMPOUNDS AND EVALUATING THE ANTIOXIDANT ACTIVITY OF LIGNIN ISOLATED FROM ELEPHANT GRASS

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Lignin, despite being one of the most abundant biopolymers in nature, is still less explored than cellulose and hemicellulose. Its industrial application is considered a challenge, so far, it has been burned to generate energy in the refinery itself. However, when lignin is broken down into smaller fractions, it is possible to obtain phenolic compounds, which are of great interest due to their high antioxidant and antimicrobial activity. To take advantage of the lignin, the concept of biorefinery was applied: elephant grass biomass was fractionated through a sequential acid-alkaline treatment, resulting in a liquor rich in xylose and a solid fraction rich in cellulose, isolating lignin in another black liquor. Through sequential acid-alkaline treatment, it was possible to recover 60.0% (m/m) of the cellulose with a purity content of 86.1%, and also to solubilize 99.9% and 97.7% of the hemicellulose and lignin present in the biomass. To precipitate the lignin, the solution's pH was reduced to 2.0 with 72% (v/v) sulfuric acid (H2SO4) during the night at room temperature. The precipitated lignin was filtered using filter paper and dried in an oven at 55 °C until constant weight. From the precipitation, 74.2% (w/w) of lignin was recovered. To determine the total phenolic content (TFC), the Folin-Ciocalteu method was followed using a lignin concentration of 200 µg/mL. The TFC was determined using the equivalent in micrograms of gallic acid (mg GAE), for which a standard calibration curve was previously prepared in the range of 0-100 µg/mL (R2 = 0.992). The antioxidant activity was determined based on the inhibition capacity of the 2,2-diphenyl-1-picryl-hydrazyl (DPPH) free radical. For the analysis, lignin solutions of 5, 50, 100, 150, 200 and 250 µg/mL were prepared. The performance of lignin was evaluated compared to Trolox, an analogue substance of vitamin E with high antioxidant activity, for which the Trolox standard curve ranged from 2 to 50 µg/mL (R2 = 0.990). The isolated lignin from elephant grass exhibited a total phenolic content of 169.0 mg GAE/g lignin and required a lignin concentration of 198.5 µg/mL to inhibit 50% of DPPH free radicals (IC 50%). In view of this, the lignin isolated from elephant grass biomass using an acid-alkaline treatment showed considerable values in terms of antioxidant properties, demonstrating potential use, if further evaluated, in different applications: such as UV tolerance, antimicrobial and anticancer activities or as a basis for the production of nanomaterials.

ORANGE PEEL FOR SECOND-GENERATION BIOREFINERY PURPOSES: ISOLATING PECTIN AND PROSPECTING YEASTS

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Brazil accounts for approximately 60% of the world's production of orange juice. This expressive production generates ~9 million tons of vegetal waste rich in pectin, a heteropolysaccharide whose main chains are primarily composed of galacturonic acid and secondary chains of galactose and xylose. Considering this scenario, this study aimed to extract pectin and prospect yeasts from orange wastes for second-generation (2G) biorefinery purposes. To extract pectin from orange peels, 15 g of powdered residue (< 60 mm) were dispersed in 200 mL of a 0.5 M hydrochloric acid (HCl) solution (pH = 2.0). Extraction was carried out at 650 rpm and 80 °C for 2 h on a mechanical stirrer. The resulting suspension was vacuum-filtered using a Büchner funnel. The solid fraction was characterized in terms of the percentages of cellulose, hemicellulose, and lignin, yielding values of 36.20%, 18.34%, and 18.68%, respectively. The pectin-rich fraction was precipitated with 95% ethanol (P.A.) at a ratio of 1:2 for 1 h at 4°C. Subsequently, the precipitated pectin was filtered, washed with ethanol, and dried in a vacuum oven at 60 °C until constant weight was achieved. The purity of the pectin was determined based on the protein content (purity (%) = 100 – protein content) using the Kjeldahl method, employing a correction factor of 6.25 for total nitrogen. The acid extraction method resulted in the obtention of 11.75% of pectin (18.88 g/L) with a purity degree of 92.83%. Parallelly, 39 yeast strains were isolated from 1 g samples of rotten oranges. Four strains (CHAP-045, CHAP-051, CHAP-059, and CHAP-082) were randomly chosen to be evaluated in culture media, with or without adding pectinase, containing dried-and-crushed orange peel or the extracted pectin described above. All the analyzed strains were able to grow in media with pectin. For three of them (CHAP-045, CHAP-051, and CHAP-059), there was a slight advantage in the presence of pectinase, indicating that this enzyme improved the pectin hydrolysis and helped the cells to grow. However, the strain CHAP-082 stood out, displaying the same performance regardless of the presence of pectinase. Moreover, it was also able to grow in media with dried-and-crushed orange peel. Thus, the present study highlights the potential of using orange wastes in 2G biorefineries. Not only can these residues be employed for pectin extraction, but also they can be used as substrates for yeast-based bioprocesses.

ELECTROACTIVATION OF A VEGETABLE SPONGE (LUFFA CYLINDRICA) AND TESTS AS A BIOFILTER FOR BIODIESEL PRODUCTION WASTEWATER

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Brazil is one of the largest producers of renewable energy. Biodiesel is produced from renewable sources, and its role in the Brazilian energy matrix is partially replace diesel and, soon completely substitute this fossil fuel. Although it is a sustainable alternative compared to non-renewable sources, biodiesel production is not free of pollutants. This fuel contains high levels of contaminants, leading to additional costs for industries that seek to reuse the wastewater to avoid further water expenses. This study proxposes the use of a material based on Luffa cylindrica fiber, known as "vegetable sponge," as a potential biofilter for pretreating biodiesel wastewater, thus increasing its reuse in the industry and reducing treatment costs. A culture of the bacteria Shewanella amazonenis was used to accelerate the formation of an electroactive biofilm no the surface of the vegetable sponge. For this purpose, an electrochemical stimulation procedure was employed using the chronoamperometry technique. The vegetable sponge functions as a working electrode in a device similar to an electrochemical cell, where the microbial culture was electrochemically stimulated. Advanced electrochemical techniques, such as electrochemical impedance spectroscopy, were also used to obtain additional information about the resistivity and capacitance of the formed electric double layer, which showed greater indications of microbial activity in the stimulated reactor, with a charge transfer resistance (Rtc) of 62.54 O in 48 hours of treatment, whereas the Rtc in the non-stimulated reactor was around 5 kO. The efficiency of pollutant removal was evaluated by determining the chemical and biochemical oxygen demands (COD and BOD) before and after treatment assays. A reduction of 61% and 53% in BOD and COD removal, respectively, was observed for the stimulated biofilm. These results suggests that the combination of natural, low-cost materials could be an option for biodiesel wastewater treatment and the development of new biofilters as well as new electrodes for microbial fuel cells.

TREATMENT OF DAIRY WASTEWATER IN A MICROBIAL FUEL CELL INOCULATED WITH CO-CULTURE OF SHEWANELLA PUTREFACIENS AND SHEWANELLA ONEIDENSIS

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Dairy wastewater treatment is a great challenge as this effluent has a high organic load. This organic load is due to the high levels of fatty acids, nitrogen in the form of protein and nitrate, and phosphate. On the other hand, this organic matter can be used as substrate in microbial fuel cells (MFCs). In this device, electrogenic microorganisms electrochemically oxidize the organic matter in the anode compartment, releasing electrons that flow to the cathode, generating an electric current and simultaneously decreasing the organic load of the effluent. The objective of the present study was to evaluate the efficiency of the treatment of dairy effluent (pH 11.138; conductivity 3.00 mS/cm; BOD 2009.00 mg/L; COD 4220.00 mg/L) in an air-cathode MFC, formed of carbon cloth anode, carbon cathode, with platinum catalyst load. The MFC was inoculated with Shewanella oneidensis and Shewanella putrefaciens strains (50 mL of S. oneidensis inoculum and 50 mL of S. putrefaciens inoculum) in a 1:1 volume ratio, forming an OD600 of 6.62 and 3.56 respectively. An acclimation protocol was established, where two MFCs were incubated in an incubator at 30 ºC, under an external resistance of 1 k O. The control-MFC started with only 900 mL of dairy wastewater, while the treatment-MFC started with 100 mL of inoculum and 100 mL of dairy wastewater, and it was added 100 mL of dairy wastewater for 3 days, remaining under the external resistance of 1 k O for another 4 days. At the end of this period 500 mL of the dairy wastewater was added and the treatment phase was started under 0.3 k O resistance. Preliminary results showed that the treatment-MFC reached a maximum open circuit potential (OCP) of 0.638 V while control-MFC presented a OCP of 0.061 V. Furthermore, electrochemical impedance spectroscopy technique showed that resistance solution from treatment-MFC changed from 3.2 to 1.17 O while in the control-MFC changed 264 to 53.3 O. The charge transfer resistance in the treatment-MFC was only 0.83 O, about 100 times lower than the control-MFC. The Nyquist-type plot revealed distinct profiles for the MFCs, showing a diffusional component at low frequency. These results demonstrate the electrochemical activity of the electrogenic microorganisms. The treatment phase is in progress, at the end of this period additional analyses will be done to evaluate the removal of biological and chemical oxygen demand (BOD and COD).

EVALUATION OF THE DISPOSITION OF SWINE HAIR PRETREATED WITH TRICHODERMA SP. IN THE SOIL

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The growing production of animal protein results in a high generation of waste considered environmental pollutants, such as pig hair, composed of keratin. This protein has characteristics such as rigidity, making it a natural polymer. Given this, alternatives for this waste to be disposed of without harming the environment are desirable, such as biological pre-treatment that makes the trash less rigid, facilitating access to nutrients present in its structure when disposed of in the soil, and also enables the production of keratinase, one an enzyme with high specificity for residues composed of keratin. In this context, this study aimed to evaluate the final disposition of swine hair pretreated with Trichoderma sp. in the soil and its effect on the development of tomato seedlings. It also aimed to assess the production of keratinase from the pre-treatment process. As a result, the final disposal of these pretreated residues was effective since there were no significant changes in soil characteristics but increments of nutrients such as nitrogen, potassium, and calcium in tomato seedlings. Keratinolytic activity values of 326.61 ± 42.33 and 403.3 ± 71.65 U/g were obtained within 24 hours of the process. Finally, it can be concluded that in addition to not negatively affecting the environment and the development of tomato seedlings, after biologically pretreated, pig hair can act as an adsorbent of heavy metals, reducing their concentrations in the soil.

METHANE AND NITROUS OXIDE EMISSIONS MITIGATION VIA AERATION IN AQUACULTURE

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The growing demand for aquaculture products has led to a fast expansion of the sector, raising concerns about sustainability, including the net emission of greenhouse gases (GHG). A 28-day experiment was carried out to quantify methane (CH4) and nitrous oxide (N2O) emissions from fish farming residues. In a lab facility, located in Dourados (MS, Brazil), 20 polyethylene water boxes were distributed in a completely randomized design with six treatments and two replications. Five residue treatments received constant aeration: control (no residue), feed, feces, carcass, and mix (feed + feces + carcass). A single “mix” treatment was maintained without aeration (MwA). Each amount of residue was calculated according to a modal of intensive tilapia production system (100,000 L tanks), fish weighting 30 g, 50,000 fish/m3 density, feeding rate of 7% biomass, 5% mortality, and 5% feed loss. As a result, 4.2 g of feed, 2 units of fish weighing 30 g, and, feces of 40 fish/box were used per experimental unit with 80 L of water. Residues were introduced at day 0 and measurements of net GHG emissions were carried out after 1, 2, 7, 14, 21, and 28 days. Net emissions were calculated from linear emission factors obtained by data regressions with time from a portable tunable diode gas analyzer (UPGA-LGR Los Gatos Research) attached to a floating diffusion chamber with tight tubing in a closed system. The chamber deployment measurements were taken once at night and once during the daytime. GHG flux was accepted when the coefficients of determination of the regressions were > 0.90; otherwise, “zero” emission was recorded. The non-parametric Kruskal-Wallis with subsequent Dunn’s test for pairwise comparisons was used to compare the median emissions by treatments. Median emissions were significantly different ($p < 0.05$) and null for all treatments except for MA and MwA as 0,003 and 0,198 mg CH4.m-2.h-1. Median nitrous oxide was null for all treatments. The results indicate that sustained water aeration in aquaculture systems with tilapia mitigates methane emissions by at least 98% with respect to the mix and mix without aeration (MwA).

PRODUCTION OF VOLATILE COMPONENTS IN MICROALGAE CULTIVATED USING AGROINDUSTRIAL WASTES WITH DIFFERENT GROWTH PHASES

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Microalgae are a source of potential commercial interest biomolecules due to their diverse metabolic profile, and ability to synthesize different classes of organic compounds. The metabolic versatility of these microorganisms supports the possibility of biomass production based on organic sources without commercial value, such as industrial wastes. Thus, the objective of this study was to investigate the production of volatile organic compounds (VOCs) the 15 ºC from the cyanobacterium Desertifilum sp. cultivated using agroindustrial wastes in different residence times. Experimental conditions were as follows: initial inoculation concentration 100 mg. L-1, temperature 15 °C, pH adjusted to 7.6, and aeration of (1.0) volume of air per culture volume per minute and absence of light, the cell residence time of 144 hours. The volatiles were isolated by headspace solid-phase micro-extraction in different residence times (24, 48, 72, 96, 120 e 144 hours), separated by gas chromatography, and identified by mass spectrometry (SPME-GC/MS). The profile of volatiles contained 24 volatile compounds when Desertifilum sp. as cultivate heterotrophic on using agroindustrial wastes. The compound limonene was identified among the major volatile compounds formed, reaching a concentration of 54.52 µg. L-1 after 144 h. Many of the compounds detected during heterotrophic cultivation originated from alcohols (1-pentanol, propanol, 3-methyl-1-butanol), ketones (2-heptanone, benzophenone, 4-metyl-2-pentanone), terpenes (limonene, 1,8 cineole, menthol) and the sulfur-containing compounds (dimethyl disulfide, benzothiazole).

INSECTICIDAL EFFECT OF PYROLYSIS OIL FROM URBAN SOLID WASTE AND LEMON GRASS ON ANTICARSIA GEMMATALIS

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Waste disposal is a logistical challenge for governments around the world. The search for an environmentally sustainable and viable alternative for the correct disposal of this matter is frequent and linked to this, there is the search for an agriculture with less use of synthetic products. Pyrolysis, a thermochemical conversion process in an anoxic environment, emerges as an alternative destination for various types of waste, including urban solid (USW) and lignocellulosic waste, whose incorrect disposal also causes deleterious impacts on the environment. Among the three by-products generated during the process is the pyrolysis oil, the liquid fraction, which has shown potential for agricultural use given the chemical components observed in other studies. However, few studies report the real potential of USW pyrolysis oil for agricultural use. Therefore, this work aimed to verify the insecticidal potential of pyrolysis oil from MSW and lemongrass biomass in the control of Anticarsia gemmatalis. This widespread pest devastates soybean crops worldwide. Larvae of A. gemmatalis in the third stage of development were used. The slow pyrolysis process was conducted in an Auger-type reactor (infinite screw), with a heating rate of 10 ºC·min-1 and material residence time of 90 min. The pyrolysis oil of both raw materials was mixed with the diet at the concentrations of 0.1 %, 0.5 %, 1.0 %, 1.5 %, and 2.0 % v/v, plus a control (no pyrolysis oil added). Each treatment consisted of ten repetitions, with five individuals in each repetition, totaling 50 individuals, which were placed in a container where the only food offered had the treatments mentioned above. The evaluations took place at 24 h, 48 h, and 72 h after the installation of the experiment. The insecticidal effect is characterized by causing the death or difficulty of survival of insects, regardless of their stage of development, reducing the incidence of individuals, preventing their multiplication, and creating barriers to the entry of pathologies introduced by them. The pyrolysis oils of both raw materials used in the experiment were inefficient in controlling the soybean caterpillar at this stage of development and under these test conditions since they did not show a mortality rate at any of the tested concentrations. Studies carried out with Spodoptera eridania subjected topically to coffee pyrolysis oil did not show insect mortality at the same concentrations. Eucalyptus pyrolysis oil was also used with insecticidal intent against adults of Tuta absoluta, with no mortality of individuals being verified nor alterations in the development and oviposition of insects. Thus, the pyrolysis oils tested did not show an insecticidal effect against individuals of Anticarsia gemmatalis. However, more studies need to be carried out to confirm such behavior assertively.

COMPARISON OF PRODUCTION COSTS OF THE COMPOSTING PROCESS AND OTHER ALTERNATIVES TO TREAT AND DISPOSE OF SEWAGE SLUDGE GENERATED IN TWO SÃO PAULO COUNTIES

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The composting process allows the use of sewage sludge for agricultural use, unburdening sanitary landfills, reducing environmental liabilities, making possible to reduce the use of chemical fertilizers that impact the cost of production in agriculture, in addition to being a green marketing for companies of sanitation. The objective of this study was to raise the production costs of organic compounds produced with crushed city tree pruning and two sewage sludges (A and B) generated from aerobic treatment (activated sludge) in the state of São Paulo, and compare them with treatment costs with drying and turning in an oven up to a water content of 60% and disposal in a landfill (sludge A), and disposal of the waste in natura to a third-party company that performs the composting process (sludge B). The methodology for calculating the cost of production used was that of the Institute of Agricultural Economics of the São Paulo Agency for Agribusiness Technology belonging to the Secretary of Agriculture and Supply of the state of São Paulo (IEA/APTA/SAA), as described in MATSUNAGA et al (1976). For sludge A, 45.9 tons of sewage sludge and 36.7 tons of tree and/or grass pruning were used, making a total of 82.6 tons at the beginning of the process, and the total volume of organic compound generated was of 49.6 tons. For sludge B, 16.6 tons of sewage sludge and 10.2 tons of tree pruning were used, making a total of 26.8 tons of starting material, generating a final total volume of 16.1 tons of compost. The coefficients necessary for the calculation of the cost of production of organic compounds and subsequent comparison between the different systems regarding the disposal of the sludge generated in landfills were raised. For sludge A, a comparison was made with the process of drying the material in an oven and sending it to the landfill and the wet sludge also sent to the landfill. The results showed that the cost of composting was lower than the other disposal systems for the two sewage sludges. For sludge A, the cost of producing a ton of compost was 54.8% lower than the cost of disposing of dry sludge in landfills, and 26.4% of disposing of wet sludge. For sludge B, the cost of producing a ton of the compound produced was 43.7% lower than the cost of delivering the sludge to a third-party company to produce the compound. In addition to the lower production costs of the sewage sludge composting process, it should be noted that the organic compost enables revenue from its sale, which is not accounted for in this study. It also provides a reduction in the use of mineral fertilizers, improvement in soil fertility by adding organic matter and reducing environmental impacts generated by disposing of the residue directly on the soil and/or even disposing of it in landfills.

ß-CAROTENE AS THE CENTER VALUE IN SUSTAINABLE MICROALGAE BIOREFINERY: THE IMPORTANCE OF BIO-WASTE IN THE CIRCULAR ECONOMY

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The advancement of resource-efficient, ecologically sound, intersectoral, integrated value chains with low carbon footprint through biorefinery approaches to co-produce various bioproducts is essential for the transition to a circular bioeconomy. However, the current waterfall models proposed by microalgae-based systems, which consider using low-value commodities such as biomass and biofuels as the core of the biorefinery, yet not prove to be sustainable; unless the yield of high-value composts is addressed together. In light of the above, this work aims to evaluate the environmental performance of a microalgae biorefinery simulation, considering fine chemical products, such as ß-carotene, as its value center. Furthermore, we emphasize the recovery of biological waste as a fundamental strategy to circumvent the deep-rooted environmental bottlenecks in microalgae-based processes and promote a circular bioeconomy. The methodology used was a life cycle assessment tool, in accordance with the International Organization for Standardization 14040 series. This tool was applied to the seven main impact categories: global warming potential, fossil resource scarcity, stratospheric ozone depletion, land use, freshwater eutrophication, terrestrial acidification, and water consumption. The functional unit was standardized for 1 ton of ß-carotene pigment, considering the co-generation of its potential biowaste of 1.51 tons of bulk oil and 2.34 tons of defatted biomass, from the species Dunaliella salina in raceway ponds. The results showed total environmental orders of 5.53 × 105 kg CO2-eq for global warming potential, 1.21 × 105 kg oil-eq for fossil resource scarcity, 8.55 × 10-2 kg CFC11-eq for stratospheric ozone depletion, 9.78 × 102 m2 crop-eq for land use, 1.25 × 103 kg P-eq for freshwater eutrophication, 1.97 × 103 kg SO2-eq for terrestrial acidification, and 1.11 × 103 m3 for water consumption. According to the results, the contributions of the cultivation stage, harvesting, drying, pigment extraction, bulk oil, and defatted biomass for the midpoint impact categories were around 94.73, 0.37, 2.66, 1.47, 0.59, and 0.18%, respectively. In addition, bio-waste generates have the potential for application in the microalgae global market estimated at ~ 720.51 million/USD, with bulk oil being the main feedstock for bioenergy segments such as biodiesel, as well as a food supplement considering the fatty acids polyunsaturated fraction. Likewise, defatted biomass has been required as a bioresource of protein supplementation for animal and human feed, beyond the application in bioenergy, such as bioethanol production. Therefore, our study highlighted that the valorization of bio-wastes from a biotechnological high-value route, such as the production of ß-carotene, resulted in secondary bioproducts with a small if the not almost negligible, collection of ecological footprint, cost, and energy demand, under the gaze of a microalgae-based biorefinery.

ANTIOXIDANT POTENTIAL OF POLYMERIC NANOFIBERS PRODUCED WITH KERATIN HYDROLYZATE

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Due to the intrinsic biocompatibility and biodegradability of keratin, investigations evaluate its application through nanobiotechnology for different functions. In this sense, polymeric nanofibers for encapsulation of bioactive protein hydrolysates are investigated by exploring the functional properties of keratin, which can provide the development of innovative materials. The objective of this work was to manufacture polymeric nanofibers incorporated with bioactive keratin hydrolyzate (HBQ) through the electrospinning process. An enzymatic bioprocess was developed using the strain of Bacillus velezensis P45, known producer of keratinases for the hydrolysis of chicken feathers as a source of keratin. HBQ was produced through submerged cultivation (30 °C, 125 rpm, for 72 h) in mineral medium containing 10 g/L of chicken feathers. The hydrolyzate was centrifuged, and its supernatant was lyophilized and used to incorporate the nanofibers. The polymers used in the production of nanofibers were polycaprolactone (PCL) and poly(vinyl alcohol) (PVA), dissolved in tetrahydrofuran: dimethylformamide (1:1, v/v) and distilled water, respectively. Each polymeric solution was prepared at concentrations of 10 and 15%, in addition to the addition of 1, 2.5 and 5% of HBQ. For the electrospinning process, a syringe containing 1 mL of the evaluated polymer was coupled to an electrospinning machine, and the following processing conditions were applied: voltage of 20 kV; feed rate of 0.08 mL/min; needle inner diameter 0.5 mm; distance of 9 cm between the needle and the collection plate. Nanofibers without HBQ were produced as a control. The antioxidant activity of the nanofibers was evaluated in vitro through the quenching of 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radicals. Additionally, the optimization of the evaluation of the antioxidant activity by the DPPH method was performed using different contact times (30 min, 24 h, 40 h and 48 h) between the nanofibers and the radical solution. Nanofibers incorporated with HBQ showed antioxidant activity in both evaluated methods. For the in vitro assay using the ABTS radical, it was possible to verify a similar profile of antioxidant activity between the PCL and PVA nanofibers, regardless of the polymer concentration, and slightly increasing according to the concentration of HBQ added to the polymeric solution. In this case, PCL nanofibers presented ABTS radical scavenging capacity ranging from 39.48 to 43.88%, while those prepared with PVA ranged from 38.6 to 42.89%. On the other hand, the DPPH test showed better results for PCL nanofibers compared to PVA, highlighting those incorporated with 5% HBQ. In addition, the optimization of this evaluation method allowed verifying an improvement in the DPPH radical capture capacity after a longer contact time between the nanofibers and the radical solution. In this case, the maximum activity value (53.68%) was obtained for 15% PCL nanofibers after 48 hours of incubation in the radical solution. The results suggested the possibility of obtaining nanofibrous materials with interesting antioxidant potential through the electrospinning technique, incorporating HBQ into synthetic polymers. It is expected the characterization and validation of these biomaterials for application, for example, as alternatives for improving food packaging.

EFFECTS OF THE INCLUSION OF MONENSIN IN DAIRY CATTLE DIETS ON THE DEGRADATION OF FIBROUS CONSTITUENTS OF MANURE DURING COMPOSTING

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In the feeding of dairy cattle, the use of monensin as an ionophore aims to increase the productive performance of the animals. However, the excretion of monensin from manure is a concern, due to the possibility of inappropriate disposal in the environment. Thus, composting appears as an alternative to reduce monensin concentrations in waste, however, the greater inclusion of the ionophore in the animals' diet may compromise the action of microorganisms. Thus, the objective of this research was to evaluate the composting of dairy cattle manure that received different doses of monensin (0, 9, 18, 27, and 36 mg of monensin per kg of DM intake) and its influence on the degradation of fibrous constituents (neutral detergent fiber - NDF, and acid detergent fiber - ADF). The research was carried out at the Federal University of Grande Dourados, under protocol CEUA 16/2021. A Completely Randomized Design was adopted with a 5x9 factorial scheme (monensin doses x composting times), with three replications, and, times of 5, 10, 15, 20, 30, 40, 50, 70, and 90 days, using waste in its entirety or after physical separation using sieves. The concentrations of NDF and ADF were determined in the manure (initial substrate) and in all periods of evaluation of the composting time. Composting lasted 90 days, using the buried bag technique, with samples of about 80g of manure placed in nylon bags (20x10cm) that were incubated inside a windrow formed by cattle manure and with an initial capacity of 1000kg of waste. The results were evaluated independently for the sieved (S) and no sieved (NS) conditions. In the NS condition, at 5 days of composting, it was verified that the highest degradations of NDF occurred in the control group and with the inclusion of 9 mg of monensin in the diets (27.81 and 25.95%), while for the ADF the highest values were in the control group (14.95%), about the mean of the other treatments (2.10%). About the remaining period of composting, there was no influence of monensin for the NDF reductions that occurred between 5 and 90 days of the process, while for the ADF, the highest degradation occurred for treatments originating from animals that consumed the ionophore (average of 50.84%). In the S condition, a similar behavior occurred for NDF and ADF degradations at 5 days of the process, with the control treatment presenting the highest values (24.88 and 10.88% for NDF and ADF reductions), however without differing of the 9 and 18 mg monensin inclusions. For the reduction from 5 to 90 days in the S condition, an average of 46.26% was observed for NDF, without the influence of monensin, and an average of 50.10% for ADF in the substrates containing ionophores. As monensin showed a higher negative effect on the degradation of fibrous constituents in the initial period of composting, but not throughout the process, it is recommended that this technique be adopted as an alternative for the treatment of dairy cattle manure.

PRODUCTION OF ANTIOXIDANT PROTEIN HYDROLYSATES FROM MEAT INDUSTRY BY-PRODUCTS

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Slaughterhouses generate enormous amounts of by-products, such as bones, feathers, viscera, internal organs, among others, which are usually underutilized. However, due to their high protein concentration, these by-products might be suitable substrates for obtaining bioactive protein hydrolysates. Among the bioactivities of hydrolysates, attributed to peptides released during hydrolysis, the antioxidant capacity is particularly relevant considering the harmful potential of oxidative reactions in biological and food systems. Enzymatic hydrolysis is mainly applied for the production of bioactive hydrolysates, and prospecting of alternative (non-commercial) microbial proteases is a topic of growing interest. This work aimed at applying a bacterial protease to obtain antioxidant hydrolysates from meat industry by-products. Protease from Bacillus sp. CL18 was produced through cultivations (30 °C, 125 rpm, 4 days) in mineral medium containing fish scales (30 g/L) and chicken feathers (5 g/L). Culture supernatants were used as crude protease. The by-products used for hydrolysis were chicken feathers (CF), bovine lungs (BL), porcine lungs (PL), bovine kidneys (BK) and porcine kidneys (PK). Ground and boiled by-products were suspended (50 g/L) in Tris-HCl buffer (100 mM, pH 8.0, 5 mM Ca2+), pre-incubated (52.5 °C, 10 min), and hydrolyses were initiated by adding the crude protease (5% v/v; 600 U/mL). Reactions were performed for 4 h, terminated by boiling and, following centrifugation, the supernatants were collected as hydrolysates. Controls were performed using the thermally inactivated protease. Hydrolysates were evaluated for soluble protein concentration (mg/mL), quenching of 2,2-diphenyl-1-picrylhydrazyl (DPPH, %) and 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS, %) radicals, Fe2+-chelating ability (IC, %) and reducing power [RP; absorbance at 700 nm (Abs700)]. Crude protease from Bacillus sp. CL18 was able to hydrolyze all tested substrates, as detected by the increased soluble protein contents in hydrolysates (CF: 1.57, BL: 2.51, PL: 1.80, BK: 1.57 and PK: 1.92 mg /mL) in comparison to controls (CF: 0.90, BL: 0.63, PL: 0.52, BK: 0.26 and PK: 0.40 mg/mL). Regarding antioxidante potentials, the elimination of DPPH was higher in hydrolysates (CF: 7.60, BL: 4.40, PL: 5.76, BK: 5.11 and PK: 5.50%) as compared to the controls (CF: 4.24, BL: 2.26, PL: 1.74, BK: 2.13 and PK: 1.87%). ABTS quenching in controls (CF: 12.77, BL: 8.17, PL: 8.62, BK: 12.58 and PK: 19.20%) was increased to 32.04% (CF), 54.47% (BL), 49.51% (PL), 60.30% (BK) and 73.64% (PK). The IC of hydrolysates (CF: 57.80, BL: 68.71, PL: 80.10, BK: 73.41 and PK: 79.33%) was also higher than controls (CF: 28.98, BL: 53.89, PL: 46.59, BK: 65.33 and PK: 69.53%). In addition, the RP in controls (CF: 0.005, BL: 0.009, PL: 0.004, BK: 0.005 and PK: 0.011 Abs700) was lower than that observed in hydrolysates (CF: 0.053, BL: 0.055, PL: 0.026, BK: 0.045 and PK: 0.058 Abs700). In summary, the crude protease from Bacillus sp. CL18 might be a suitable biocatalyst to generate antioxidant hydrolysates. Production of bioactive hydrolysates represents a promising strategy for the valorization of meat industry by-products within a biorefinery perspective.

THE IMPACT OF MONENSIN ON THE VOLATILE SOLIDS REDUCTIONS DURING DAIRY COW MANURE COMPOSTING

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Monensin is an ionophore widely used in dairy cattle because it reduces energy losses due to its anti-methanogenic action. However, as it is excreted in animal feces, correct management of these residues is recommended, with composting being an alternative to promote the reduction of monensin concentrations in organic fertilizer. The separation of fractions can be adopted to reduce these concentrations in waste and have less impact on the performance of microorganisms during composting. This work aimed to evaluate the reduction of volatile solids (VS) during the composting of dairy cow manure, sieved or not (S or NS), fed with different inclusions of monensin. The work was conducted at the Federal University of Grande Dourados, under protocol CEUA 16/2021. The manure was collected from Jersey animals that received doses of 0, 9, 18, 27, and 36 mg of monensin per kg of DM intake. A completely randomized design was adopted with a 5x9 factorial scheme (monensin doses x composting times), with three replications, with times 5, 10, 15, 20, 30, 40, 50, 70, and 90 days. Results were evaluated independently for the S or NS condition. The buried bag technique was used for waste composting, weighing about 80g of manure in each nylon bag (20x10cm) and incubating inside a windrow with field capacity (1000 kg) and formed by cattle manure. Temperatures were measured daily, and the process was completed after 90 days of beginning. The VS reductions at five days of composting were inhibited by the presence of monensin, and in the NS condition, the highest reductions ($p<0.05$) occurred for substrates at doses of 0 and 9 mg, with values of 27.81 and 25.95%, respectively, while the other monensin conditions were similar, with an average of 14.60%. In the NS condition, monensin doses did not influence the VS reductions ($p>0.05$), considering the remaining composting time, from 5 to 90 days. At the end of composting, it was possible to reach values of up to 70.23% VS reduction for the dose of 9 mg of monensin and a minimum of 59.68% for 36 mg. The windrow temperature remained in the thermophilic range (above 45ºC) for more than 30 consecutive days, and possibly acted decisively in the reduction of monensin during the process. In condition S, at 5 days of composting, the manure containing 0 mg of monensin showed the highest VS reduction ($p<0.05$; 24.88%), while the lowest value was for the inclusion of 36 mg (12.54%). The VS reduction from 5 to 90 days was not influenced by the inclusion of monensin in the diets ($p>0.05$). At the end of composting, in the S condition, the control achieved a VS reduction equal to 70.50%, while the inclusion of 36 mg presented the lowest reduction (58.65%). It is concluded that the presence of monensin interferes with the VS reduction in the initial period of composting, but with the development of the process and temperature increase, these inclusions did not affect the VS reductions.

QUALITY OF COMPOST GENERATED FROM DAIRY CATTLE MANURE FED DIFFERENT DOSES OF MONENSIN

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One of the main ways of recycling nutrients from manure is through composting, with dairy cow manure being quite representative of the waste generated by livestock, as it is one of the main activities of Brazilian agribusiness. However, the use of monensin as a performance enhancer is common and this product is excreted mainly through the feces, which can impair the recycling processes and the quality of the generated product. The separation of the solid-liquid fraction can be used in the waste to reduce loads of antibiotics and not impair the performance of microorganisms nor reduce the quality of the fertilizer generated. The objective of this work was to evaluate the quality of the compost from dairy animal manure fed with different doses of monensin and with solid-liquid separation. The work was carried out at the Federal University of Grande Dourados, under protocol CEUA 16/2021. Manure was produced from Jersey animals fed with doses of 0, 9, 18, 27, and 36 mg of monensin per kg of DM intake. A Completely Randomized Design was adopted with a 5x9 factorial scheme (monensin doses x composting times), with three replications, and, with times of 5, 10, 15, 20, 30, 40, 50, 70, and 90 days. The results were evaluated independently for the sieved (S) and no sieved (NS) conditions. Analyzes of N, P, and functional groups were performed in FTIR (Fourier Transform Infrared Spectroscopy). The buried bag technique was used to compost the waste, weighing about 80g of manure in each nylon bag (20x10cm) which was incubated inside a windrow with field capacity (1000 kg) and formed by cattle manure. The process was considered completed after 90 days. At 5 days of composting, the N reductions in the NS condition were not influenced by the monensin doses ($p>0.05$) with an average of 5.86%, but when the reduction was evaluated in the period from 5 to 90 days, the lowest values occurred in 0 mg (25.8%). For condition S, at 5 days the lowest N reductions ($p<0.05$) occurred in the inclusions of 0 and 27 mg (8.2 and 7.6%, respectively), and from 5 to 90 days, the lowest values were to 0 mg (24.4%). The mean N concentration with S was 26.7 g.kg-1, with no difference between monensin inclusions. The initial P concentration in the S condition was higher when 36 mg of monensin was included in the diet, but there was no difference between treatments ($p>0.05$) in the final concentration, with an average of 10.1 g of P.kg-1 of fertilizer. For the evaluation of the functional groups present in the composts, it was possible to observe that in both sieving conditions, the bands were concentrated around 1620 cm-1, which is associated with the presence of aromatic compounds, indicating the maturation of the organic matter. It is concluded that the doses of monensin in the diets did not influence the quality of the generated composts, allowing to obtain fertilizers with the presence of maturated components, N and P.

LIQUEFACTION OF BANANA PSEUDOSTEM FOR RIGID FOAM PRODUCTION

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The search for sustainable and environmentally friendly alternatives has stimulated the search for new materials, mainly those derived from renewable sources and previously discarded residues. The commercial production of bananas emerges as a potential source of lignocellulosic residues. For every 100 kilos of banana harvested, approximately four tons of lignocellulosic residues (pseudo-stem and leaves) are generated. Thus, researchers are exploring technological alternatives to transform these residues into valuable products. A promising approach involves the use of banana pseudostem as raw material in biorefineries, given its rich composition of cellulose, hemicellulose and lignin. These residues may be used in the liquation process in order to produce biopolyol, which is a precursor for the production of polyurethane (PU) foams. These foams are widely applied in industries such as thermal insulation, furniture, automotive and footwear. In this context, the objective of this work was to produce rigid foams using biopolyol. The liquefaction of the residues from banana production was performed, in order to evaluate the better experimental condition to obtain biopolyol and, also to evaluate the properties of the biopolyol produced. Liquefaction used pseudostem as biomass and crude glycerol as solvent. We observed the highest liquefaction yield was above 88 % by weight. The properties from the biopolyol obtained in the best experimental condition were: density 1.33 g/mL, viscosity 160 mPa .s and hydroxyl number 829 mg/g KOH. Rigid foams were produced using this biopolyol. The qualitative analysis demonstrated that these innovative foams, derived from the liquefaction of banana pseduostem and crude glycerol, are rigid and exhibit good dimensional stability. It can be stated that the results obtained in this first moment were satisfactory. This study aims to add value to a previously discarded waste, thus contributing to economic circularity and sustainability. The research into these technologies represents a crucial advance in the search for green and efficient alternatives, promoting the preservation of resources and reducing the environmental impact.

STRUVITE PRECIPITATION: ELEMENTARY ANALYSIS OF PRECIPITATED CRYSTAL USING ALTERNATIVE SOURCES OF MG FOR LATER APPLICATION ON SWINE PRODUCTION WASTE

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Struvite (MgNH4PO4·6H2O) is a mineral commonly found in wastewater treatment plants and composting processes. When, under favorable conditions, magnesium, ammonia and phosphate comes together, struvite crystals are formed and compromises pipelines, bombs such as others compounds of a WWTP. On the other hand, struvite precipitation process enables concurrent recovery of N and P from residual waters. Also, struvite is a slow-release fertilizer with low solubility, making it a sustainable alternative to conventional N and P fertilizers and reducing the dependence of imported fertilizers. The objective of this work was to evaluate the efficiency of the struvite precipitation process as from alternative sources of Mg compared to commercial ones. So, hereafter in a later study, apply or not the addition of Mg in raw struvite precipitation process produced by swine production waste. The present study was conducted in bench scale by precipitating struvite with commercial sources of PO43- (KH2PO4), NH4+ (NH4Cl) and Mg2+ (MgCl2·6H2O and MgSO4·7H2O) and also two low-cost alternative sources of Mg2+: Magnesite (MgCO3) and a fertilizer rich in MgO used in organic agriculture. Experiment was conducted under optimum operation conditions: NH4+, PO43- and Mg2+ salts were added in a way NH4+ and Mg2+ concentrations in solution were 10 g/L and PO43- concentration was 40 g/L. All solutions were pH adjusted to 9,5. The results of elementary analysis of the precipitated phase combined with x-ray diffraction analysis confirmed that the crystals obtained were struvite and newberyite. Since struvite's typical composition is around 5% of N, 12% of P and 10% of Mg, and N and P levels for the four sources of Mg were: MgCl2·6H2O (4,487% of N and 12,007% of P), MgSO4·7H2O (4,500% of N and 12,218% of P), MgO (4,852% of N and 11,743% of P) and MgCO3 (4,844% of N and 11,029% of P), N and P levels were considered acceptable according to the literature. Mg levels were slowly low on the three last precipitates (MgCl2·6H2O: 9,579% of Mg), MgSO4·7H2O (6,053% of Mg), MgO (6,142% of Mg) and MgCO3 (5,988% of Mg) probably because of the formation of MgOH2 and the difficulty, in the case of the alternative sources, in precipitating struvite from sources where Mg was chelate. The presence of newberyite is justified by the fact that it's a product of the decomposition of struvite and they both can coexist for being thermodynamically stable under specific conditions. In conclusion, alternative sources showed to be viable for the conduction of the experiment using digestate from swine farming.

ANAEROBIC DIGESTION OF DAIRY CATTLE MANURE FED DIFFERENT DOSES OF MONENSIN AND SEPARATION OF SOLID-LIQUID FRACTION

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Anaerobic digestion (AD) is one of the most adopted waste treatments in dairy cattle due to the high amount of water used to clean the facilities. It is a very common practice to use monensin in animal feed as a ruminal modulator, to reduce energy losses with methane formation. However, animals excrete monensin through feces and urine that will go to the biodigester, which can harm the process. Separations of the waste fraction can be adopted to reduce the monensin load in the AD affluent, in addition to reducing the solid fraction that is more difficult to digest, thus making the process more efficient. The objective of this work was to evaluate the potential of biogas production and total solids (TS) reductions in the digestion of dairy cattle manure fed with increasing doses of monensin and solid-liquid fraction separation. The work was conducted at the Federal University of Grande Dourados, under protocol CEUA 16/2021. The manure was collected from Jersey animals fed with doses of 0, 9, 18, 27, and 36 mg of monensin per kg of DM intake. A Completely Randomized Design was adopted, with a 5x2x2 factorial scheme (monensin doses x hydraulic retention times x sieving), with three replications. The hydraulic retention times (HRT) were 20 and 30 days (HRT20 and HRT30) and the TS concentrations in the affluents were 2.5% for no sieved substrates (NS), while for sieved substrates (S) the TS concentration was lower than this, after retaining the coarser fraction on the sieve. The results were evaluated independently for the HRT tested. The TS reductions with HRT30 were greater in S substrates, with a maximum value equal to 54.20% in the control treatment, indicating a decrease in reductions according to the monensin inclusion in the animals' diet. Similar behavior was verified in the NS condition, with a decrease in the reductions according to the increase in the monensin dose (45.06% for the inclusion of 36 mg). The biogas production potentials in HRT30 were maximum for the control condition, with values of 233.17 and 143.31 liters/kg of TS added and decreasing as the inclusion of monensin in the diets increased. In HRT20 the average of TS reductions were 43.78 and 37.64%, resulting in biogas production potentials of 128.92 and 89.58 liters/kg of TS added for conditions S and NS, respectively. In both sieving conditions, in HRT20, the maximum specific biogas productions occurred in the control treatment (168.78 and 99.01 liters/kg of TS added for substrates S and NS, respectively). According to the results, it is concluded that performing the sieving, as well as promoting a higher HRT of the substrates, are essential to increase its degradation during the AD of the manure originated by dairy cattle consuming increasing doses of monensin in the diet.

PHYSICAL-CHEMICAL CHARACTERIZATION OF GRAPE SKIN RESIDUE FROM THE PROCESS OF ELABORATING ORGANIC WHOLE GRAPE JUICE

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The state of Rio Grande do Sul is the leading producer of grapes, wines, and juices in the country. The main cultivars are American and hybrid grapes, intended mainly for producing juices and table wines. The production and consumption of whole grape juice are increasing in Brazil, mainly due to its nutritional properties. In preparing integral grape juice using the Welch method, which uses grape heating to extract the color, the primary solid organic residue generated is grape pomace. In general, grape processing residues are destined for composting or animal feed. However, to value these residues, it is essential to characterize them so they can be reused in other products with greater added value. Grape skins represent approximately 50 wt.% of grape pomace. However, the proportion of skins and seeds can vary depending on the grape variety and growing conditions. In this context, this study reports the characterization of grape skin waste regarding dietary fiber, total phenolic compounds, and total anthocyanin contents. The grape skin residue evaluated was from the Bordô variety (Vitis labrusca L.), of organic origin, generated in the process of making whole grape juice, 2018 harvest, available dry (70±2 °C for 12 h) and donated by a company located in the municipality of Garibaldi. After receiving the residue, manual separation was performed so that other plant fragments were absent. Grinding was performed in a knife mill and screening with a mesh/Tyler 9 sieve (2.0 mm). That is, the granulometry obtained was less than 2.0 mm. Total dietary fiber was determined through enzymatic digestion and gravimetry, the content of total phenolic compounds was determined by the colorimetric method of Folin-Ciocalteau, and the content of total anthocyanins was determined by the differential pH method. The dietary fiber content obtained was 54.1 wt.%, with 51.7 wt.% of insoluble fiber composed mainly of hemicellulose. The total phenolic content of the residue obtained was 1,530 mgEAG/100 g, and the anthocyanin content was 88.8 mgECG/100 g. The grape skin residue showed high fiber, total phenolic, and anthocyanin contents, suggesting that it is a source of dietary fiber and antioxidants with the potential for use as a raw material in the preparation of food products. In addition, the use of agro-industrial residues rich in lignocellulosic fibers and antioxidants in packaging makes it possible to add this grape residue to the polymeric matrix to improve the properties, such as, for example, of starch foams, due to the residues being mainly composed by insoluble fibers (cellulose, hemicellulose, and lignin).

DEVELOPMENT OF FOAMS BASED ON CASSAVA STARCH WITH INCORPORATION OF GRAPE SKIN WASTE

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The generation of non-biodegradable waste from food packaging is growing, and often due to the economic unfeasibility of the segregation and recycling process, these wastes are sent to landfills. This study sought to develop and obtain foams based on cassava starch with the incorporation of the agroindustrial waste of grape skins from the production of organic whole grape juice to application in food packaging, aiming at reducing the environmental impact and obtaining alternative biodegradable materials. Foams based on cassava starch with the addition of 30 wt.% of grape skin residue were produced by thermal expansion. The obtained foams were characterized relative to apparent density, moisture content, and water absorption capacity. The apparent density of the foams was determined from the relationship between the mass and the volume of the samples. The moisture contents of the starch-based foams were determined by the thermogravimetric method. The water absorption capacity of the foams was determined according to the Cobb methodology, with adaptations. With the addition of the grape peel residue obtained, the cassava starch solution presented a homogeneous visual appearance and no apparent separation. In contrast, the foam showed the characteristic coloration of the added residue. The apparent density of the foam obtained was 0.118 g·cm -3; the addition of residue decreased the apparent density, with a significant difference in the sample with the addition of residues concerning the control sample (without the addition of the waste). This result can be attributed to adding residue acting as a reinforcing load, providing greater expansion capacity of the starch solution, resulting in more expandable materials. Regarding the moisture content, the result obtained was 8.14 %, while the addition of the residue in the foam provided an increase of 254 % in the moisture content relative to the control because, at the time of processing, it was necessary to the reduction of the thermopressing time so that the foam did not rupture during demolding. The addition of grape skin residue in forming starch foams provided greater water absorption capacity, with a significant difference between the control sample. The result obtained was 329 %, an increase of 13.4 % relative to the control sample. The greater water absorption capacity of the foams with the incorporation of the residue can be related to the lower apparent density of the foams, allowing greater water absorption. The incorporation of grape skin residue provided the obtainment of cassava starch foams with lower apparent density, higher moisture content, and greater water absorption capacity, making this residue a potential raw material for application in the production of food packaging dry, which have low unit content, with biodegradable characteristics and less impact on the environment.

DEVELOPMENT AND CHARACTERIZATION OF A MIXED MATRIX BIOPOLYMER BASED ON PVA AND WHEY

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Synthetic polymers, due to their non-biodegradability, persist for too long in the environment, generating impacts and environmental liabilities that are difficult to control and remediate. In contrast to such polymers mentioned above, there are biodegradable polymers whose decomposition is accelerated and carried out by various microorganisms (bacteria, fungi, and algae. The main applications for biodegradable polymers include materials for packaging, disposable non-woven fabrics, hygiene products, and goods consumables, among other potential applications. Whey-based polymers are biodegradable, biocompatible, and safe for contact with food, making them a sustainable alternative to synthetic plastics. In addition, they have adequate mechanical and physicochemical properties and the ability to form thin, transparent films. Several techniques for producing whey-based polymers include spray dehydration, acid coagulation, and thermal denaturation. These processes involve the separation of whey protein from other milk components, followed by purification and processing into a polymeric matrix. Whey-based polymers have potential applications in several sectors, including food packaging, medical devices, textiles, and cosmetics. They represent a promising alternative to traditional polymeric materials, contributing to sustainability and developing a circular economy. In this study, different additives were tested for the formulation of a biopolymer based on whey and polyvinyl alcohol (PVA). As additives, sorbitol, glycerol, and citric acid were tested. The films were produced by the casting process, in which the prepared solutions were poured into Teflon-coated Petri dishes, with 20 mL of solution added to each plate. The solutions were kept in a room at 23±2 °C and relative humidity of 60% for 48 h for drying. Subsequently, the films were removed from the plates and dried in an oven at 60 – 65 °C for 2 h. After being removed from the oven, the films were cooled and packed in plastic bags, protected from sunlight and moisture. Regarding the appearance of the produced films, it can be noticed that even changing the chemical components of the formulations, the different ingredients used do not alter the film formation process. However, using some substances showed a better performance in forming films, highlighting some with better resistance, less elasticity, or even more brittle. Thus, it becomes necessary to evaluate in detail which combinations of components (plasticizer, crosslinker, fillers) will generate a whey-based biopolymer with physicochemical and mechanical properties that meet the needs for use in place of non-biodegradable polymers and/or from a non-renewable source.

REUTILIZATION OF MALT BAGASSE AND BIOSOLID IN THE PRODUCTION OF FOREST TREE SEEDLINGS

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Within the forest nursery production process, container and substrate are determining factors in seedling growth. In the present study, the effect of containers made from malt bagasse residue and biosolids from sewage sludge treatment, as substrates, was evaluated for the production of Cytharexyllum myrianthum seedlings, widely used in forest restoration plantations. The experiment was conducted at the "Arboretum" Interinstitutional Program forest nursery, located in Teixeira de Freitas, Bahia, Brazil. The experiment was conducted from April to August 2022. A completely randomized design in a 3x2 factorial scheme was adopted, with three containers (polypropylene container (PP) with 110 and 180 cm3 volume, and malt bagasse with 110 cm3) and two substrates (commercial and biosolid from sewage sludge). The commercial substrate used was Topstrato®, composed of pine bark, vermiculite, and charcoal. The commercial substrate received base and cover fertilization practices by nursery. The biosolids were donated by the State Company of Water and Sewage (CEDAE) from the Ilha do Governador Sewage Treatment Plant, located in Rio de Janeiro, Rio de Janeiro, Brazil, and did not receive any fertilization. Micro-sprinkler irrigation was applied daily to avoid water limitation. Height of the aboveground part (H) and collar diameter (DC) growth evaluations were measured at 30, 60, 90, and 120 days after sowing using a graduated meter and digital caliper. The data were subjected to analysis of variance, and when the calculated F-value (Fc) was significant, Tukey's mean test was applied at 5%. The analysis of variance showed a significant effect for the container and substrate factors, but without interaction between them, for the height (Fc = 35.285; Fc = 61.034; p>0.01) and collar diameter (Fc = 67.438; Fc = 7.859; p>0.01) parameters at 120 days after sowing. For variable H, the seedlings produced in the PP containers with 180 cm3 volume and malt bagasse showed statistically equal growth, but superior to the seedlings produced in the 110 cm3 PP container. For variable DC, the seedlings produced in the malt bagasse were superior to the others, and the seedlings in the 180 cm3 PP container were superior to the seedlings in the 110 cm3 PP container. For both variables, the commercial substrate produced seedlings with superior growth. Despite having a smaller volumetric capacity, the malt bagasse container enabled similar H growth and superior DC growth, which can be justified by the fact that the seedlings nourish themselves from the nutrients contained in the malt bagasse, which does not occur in the PP container. Thus, the malt bagasse container is able to fulfill the function of being both container and substrate, partially meeting the nutritional demand of the seedlings. The malt bagasse container (110 cm3) can replace polypropylene containers (180 or 110 cm3) since the seedlings showed similar height growth and superior collar diameter growth. The fertilized commercial substrate improved seedling growth in height and stem diameter. However, biosolid, as a waste product with high nutritional content, can significantly reduce costs for substrates and fertilizers.

COMPARATIVE STUDY OF OILY WASTE FOR BIOSURFACTANT PRODUCTION BY PSEUDOMONAS SP. ISOLATED FROM A BIOPURIFICATION SYSTEM

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The growing industry concern for sustainable processes and exploiting eco-friendly products drives the increasing interest in biosurfactants. Indeed, biosurfactants are considered less toxic and more biodegradable than their synthetic counterparts and can be obtained from sustainable sources. Biosurfactants are an extensive group of amphipathic molecules produced by microorganisms such as bacteria, yeasts, and fungi. Besides, they have efficient surface-active and biological properties applicable in several industries and processes. Biosurfactant-producing bacteria can be found in contaminated environments, such as soils receiving pesticide applications constantly or in pesticide treatment systems. Pseudomonas species are well known to produce biosurfactants. In this context, Pseudomonas sp. (C9), isolated from a biopurification system, was previously investigated as a biosurfactant producer. This study aimed to compare the effect of various carbon sources with a fixed nitrogen source (KNO3) for synthesizing biosurfactants using a Pseudomonas sp strain.
The carbon sources used were glycerol, waste residual glycerol, waste cooking oil, and ground potatoes at a concentration of 3% (w v-1). Olive oil was used as a control. All fermentations were conducted at 25 ± 1 °C, with final pH 8.5, orbital agitation at 220 rpm for 72 hours. Biosurfactant production was verified in the cell-free supernatant (CFS) (centrifugation at 10.000 rpm x 15 min at 4 ºC), evaluating pH, surface tension (mN m-1), and bacterial growth (g L-1). Biosurfactant production was strongly favored by waste residual glycerol and waste cooking oil. The surface tensions of the medium relative to water were reduced from 72.01?mNm-1 to 27.95 mNm-1 and 28.55 mNm-1 for biosurfactants from waste residual glycerol and waste cooking oil as carbon sources, respectively.
Waste residual glycerol and waste cooking oil were efficient substrates for biosurfactant production, revealing promising results concerning surface tension decrease. Therefore, these results suggest that the P. marginalis strain can produce biosurfactants from an inexpensive carbon source with potential environmental biotechnology applications.

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GEOFERT: DIGITAL SYSTEM FOR MONITORING THE APPLICATION OF PIG SLURRY AS FERTILIZER

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In regions where intensive animal production is concentrated, one of the great challenges is the correct management of waste. Pig production is the one that presents the greatest difficulties, given the high organic load present and the fact that the manure is handled predominantly in liquid form. Due to these characteristics, pig farming is considered by legislation as a potentially polluting activity. To obtain the environmental license, the pig farmer must meet a series of requirements related to the location of the facilities, structures for storing the pig slurry. When the pig slurry is used as an organic fertilizer, it must respect a balance that demonstrates the balance between the supply of nutrients and the nutrient demand of the areas to be fertilized. If the pig farmer does not have enough agricultural area to meet this balance, he has two options: 1) reduce the size of his herd according to the available area capacity; 2) sign “assignment contracts”, third-party areas in conditions to take advantage of them. In regions where small properties predominate, as is the case in the West of Santa Catarina, the most frequent situation of pig farms is that of dependence on areas for concession. This condition demands a large movement of vehicles, usually tractors coupled with a tank with a capacity of 4 m3, to carry out the service. However, this movement has been carried out without an adequate monitoring process, limiting the necessary verification with environmental agencies. Aiming to facilitate this monitoring, as well as to improve the municipal fleet management process, it was developed within the scope of the project “ Development of an environmental management model for areas with intensive animal production in the South of Brazil ”, funded by Embrapa Research Macroprograms, the prototype of a digital waste management system called “ Geofert ”. The first version of Geofert was tested within the fleet of machines of the Municipal Department of Agriculture and Environment (SMAMA) in the municipality of Presidente Castello Branco, SC. The system consists of a combination of a geopositioning device (GPS) in the vehicles that transport waste to a Geographic Information System (GIS), built from data from the Rural Environmental Registry (CAR). Initially, the construction of the prototype used the Arduino platform to obtain the geographic positioning data of the vehicles. Later, an Android application was integrated into the prototype, allowing the geographic coordinates to be obtained by smartphone. This evolution also made it possible to include functionalities such as scheduling services and issuing management reports through a web interface. The prototype met the objectives perfectly, as it allowed identifying the route, time and place of application of the biofertilizers, as well as generating reports with the necessary information for “ legal proof”. In addition, the data generated by the Geofert system can be linked to other databases, generating information of interest to users, such as operational control of fleets and streamlining service scheduling.

USE OF WASTE AS FERTILIZER

PHOSPHORUS RELEASE IN SOIL FERTILIZED WITH NPK ORGANOMINERAL FERTILIZERS BASED ON SWINE MANURE COMPOST

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The production of organomineral fertilizers from agricultural waste has potential to supply nutrients to production systems and is an environmentally appropriate way of disposing of organic waste. In Fertilizer Technology Laboratory at Embrapa Solos, NPK organomineral fertilizers were produced based on swine manure compost, five for conventional production, and three adapted for organic production systems. The objective was to evaluate the release of phosphorus from NPK organomineral fertilizers in the soil, under laboratory conditions. For a dosage equivalent to 100 mg of P, ten fertilizers were applied in plastic cups containing 100 g of soil Argissolo Vermelho Amarelo, using the eight organomineral fertilizers based on swine manure compost, two commercial phosphate fertilizers, MAP and Termophosphate, in addition to a control without fertilization (control), in a completely randomized design with three replications and seven collection periods (1, 7, 15, 30, 45, 60 and 90 days). After fertilization, the water soil content in each plot was maintained at field capacity. After each incubation period, the soil was dried, crushed and sieved, and subsequently taken for analysis of the levels of available P in the soil. Statistical analysis showed that there was a difference between the treatments in the evaluated collections, and proving that all fertilizers increased the levels of available P with their application to the soil. The levels of P available in the control ranged between 4.2 and 6.6 mg kg-1, indicating that they are soils with low P availability, serving as an excellent indicator of soil fertility. Treatment with MAP showed a high value of 180.0 mg kg-1 with one day of incubation, and in the rest of the collections available P stabilized between 43.0 and 62.4 mg kg-1. Among the organomineral fertilizers with MAP and KCl in its formulation, the treatment with the addition of MgO and micronutrients showed the highest levels of available P, being only lower than the treatment with MAP with one day of incubation, and then the highest value, varying between 104 and 165 mg kg-1. The treatment fertilized with thermophosphate, on the other hand, showed low levels up to 7 days of incubation with 45.4 mg kg-1, and between 15 and 45 days, it reached the highest values, between 106.0 and 136.7 mg kg-1, and reducing below 76 mg kg-1, in the last collections. The organomineral fertilizers adapted for organic agriculture showed levels of available P always lower than the treatment with thermophosphate and potassium sulfate, except for the treatment with the addition of MgO, bentonite, potassium silicate and micronutrients, which in the last collection reached high levels of 189 mg kg-1. These results demonstrate the ability of organomineral fertilizers based on swine manure compost to supply phosphorus to the soil, compared to commercial phosphate fertilizers.

POTASSIUM RELEASE FROM ORGANOMINERAL AND MINERAL FERTILIZERS UNDER LABORATORY CONDITIONS

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The production of organomineral fertilizers from agricultural waste has the potential to supply nutrients to production systems and is an environmentally appropriate way of disposing of organic waste. Four NPK organomineral fertilizers were produced based on swine manure compost, being three adapted for organic production systems, in the Fertilizer Technology Laboratory from Embrapa Solos. The objective of this work was to evaluate the release of potassium from organomineral fertilizers in the soil, under laboratory conditions. In each plot, an amount equivalent to 10 mg of K was added, according to the K content of the fertilizers. Each plot corresponded to a plastic cup containing 100 g of Planossolo Háplico soil. The seven treatments in the research were the four organomineral fertilizers, two commercial fertilizers, potassium chloride (KCl) and potassium sulfate (K2SO4), and a control without fertilization (without potassium), in a completely randomized design with three replications and six collection periods (2, 7, 15, 42, 90 and 180 days). After fertilization, soil moisture in each plot was maintained at field capacity. After each incubation period, the soil was dried, crushed and sieved, and subsequently taken for analysis of the exchangeable K content of the soil. In all six collections, there was a statistical difference between the treatments with fertilization and the control without fertilization, indicating the effect of potassium application in the soil. The potassium contents in the control varied between 2.3 and 3.5 mg kg-1 during the study period, indicating a soil of very low fertility. In the first collection, the levels of exchangeable K+ in the soil varied between 35.7 and 47.6 mg kg-1, with no significant difference between treatments with fertilization. In the collections carried out at 7, 15 and 42 days after fertilization, the exchangeable K+ contents in the soil varied between 18.9 and 46.2 mg kg-1. At the end of the study, in the collection at 180 days, there was a statistically significant difference between the treatment fertilized with KCl, with 94.5 mg kg-1, and all other treatments, with levels varying between 35.1 and 50.3 mg kg -1. Knowing that the amount of potassium added in each treatment was the same, it could be observed that KCl was more effective in increasing the levels of exchangeable K in the soil, approaching the expected content of the nutrient in the soil, of 100 mg kg-1 . Potassium sulfate, able to organic production systems, was also effective in increasing exchangeable potassium levels, although with lower solubility compared to KCl. The behavior of the organomineral fertilizers, both those produced with K2SO4 and that produced with KCl, were similar to each other and similar to the exclusive fertilization treatment with K2SO4, which may be an indication of the slower release of potassium in the soil. These results demonstrate the ability of organomineral fertilizers based on swine manure compost in supplying potassium to the soil, compared to commercial fertilizers.

AGRO-INDUSTRIAL WASTE AND SOLID SWINE MANURE COMPOSTED AS A SOURCE OF PHOSPHATE FERTILIZATION IN SOYBEAN CROP

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The soils of the Cerrado are poor in nutrients, so the use of fertilization, especially phosphate, is recurrent. Because phosphate sources are not renewable and the large amount of waste that is generated in the breeding of pigs and poultry that need to be disposed of correctly, these residues have been increasingly used in soil fertilization. Thus, the objective was to evaluate plant development and soybean yield in soils fertilized with agro-industrial residue and solid swine waste. The experiment was developed at the University of Rio Verde, Rio Verde, GO, under field conditions, in a randomized block design, with seven treatments, as follows: Agro-industrial waste (CA) at doses of 2.5, 5.0 and 10 Mg ha-1, behaved solid swine manure (DSS) at doses of 11.67, 23.34 and 46.68 Mg ha-1, equivalent to 40, 80 and 160 kg ha-1 of P2O5, respectively, plus an additional treatment with 174 kg ha-1 of triple superphosphate (80 kg ha-1 of P2O5), with four replications. The following were evaluated: plant height (AP), mass of one thousand grains (MMG) and yield (PROD). The data were submitted to multivariate analysis of variance by Wilks' Lambda test, Pillai's Trait, Hotelling-Lawley Trait ($p<0.05$), and then grouped by the Ward method (formation of homogeneous groups by the lowest minimum internal variance). The treatment groups were discriminated according to PA, MMG and PROD using canonical discriminant analysis. 95% confidence ellipses were constructed in order to detect statistical differences ($p<0.05$) between treatment groups. There were significant differences between the treatments, with the formation of five treatment groups, being GI: Mineral fertilization; GII: 11.67 Mg ha-1 of DSS; GIII: 23.34 Mg ha-1 of DSS; GIV: 2.5 and 10 Mg ha-1 of CA; and GV: 5 and 46.68 Mg ha-1 of CA and DSS, respectively. The plants grown in soil fertilized with 23.34 Mg ha-1 of DSS, which corresponds to 80 kg ha-1 of P2O5 (GIII) had the highest AP and MMG, with an average height of 50 cm and MMG of 195.63 g. The highest yields were obtained with the use of 11.67 Mg ha-1 of DSS (GII) and mineral fertilization (GI), which had an average yield of 3552.19 and 3375.67 kg ha-1, respectively. The fertilization with agro-industrial residue presented intermediate results. Soil fertilization with 11.57 Mg ha-1 of DSS (40 kg ha-1 of P2O5) provides soybean grain yield similar to that of soil fertilized with 174 kg ha-1 of triple superphosphate.

DEVELOPMENT OF SOYBEAN PLANTS, CARBON STOCK AND RESIDUAL EFFECT OF PHOSPHORUS AND POTASSIUM IN SOILS FERTILIZED WITH SOLID SWINE MANURE AND AGRO-INDUSTRIAL WASTE COMPOSTED

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Fertilization is indispensable in the soils of the Brazilian Cerrado and due to the large amount of waste generated in poultry and pig farming, and these are rich in nutrients, its uses in fertilization have been increasingly adopted. An important characteristic of fertilizers is their residual effect, which is characterized by the gradual release of nutrients into the soil, which prolongs the benefits. Thus, this study aimed to evaluate the effects of soil fertilization with solid swine manure (DSSC) and agro-industrial waste composted (RA) on the development of soybean plants and its residual effect on the supply of phosphorus (P) and potassium (K), and organic carbon (Corg). The experiment was developed under field conditions at the University of Rio Verde, Rio Verde-GO, in a randomized block design, with 10 treatments arranged in a 2 x 4 + 2 factorial scheme, being: DSSC at doses of 5.84, 11.67, 23.34 and 46.68 Mg ha-1, and RA at doses of 1.25, 2.5, 5 and 10 Mg ha-1, and the equivalent of 20, 40, 80 and 160 kg ha-1 of P2O5, respectively, plus two additional controls, one with 174 kg ha-1 of triple superphosphate -SFT (80 kg ha-1 of P2O5) and another without fertilization, with four replications. The height of plants at the phenological stage R2 and the levels of P, K and Corg in the soil after soybean cultivation were evaluated. Data were submitted to multivariate analysis of variance using Pillai's Trait, Wilks' Lambda and Hotelling-Lawley Trait tests ($p<0.05$). The 95% confidence ellipses were constructed to detect significant differences ($p<0.05$) between treatments. There was a difference between the treatments, in which plants grown in fertilized soil with 174 kg ha-1 of SFT and 23.34 Mg ha-1 of DSSC had higher heights, ranging from 46 to 53 cm, followed by plants grown in fertilized soil with 46.68 and 11.67 Mg ha-1 of DSSC. The highest levels of P (6.2 mg dm-3), K (250.5 mg dm-3) and organic carbon (20.4 g kg-1) in the soil were obtained in the soil fertilized with 46.68 Mg ha-1 of DSSC. Fertilization with RA compared to SFT and DSSC had less effect on plant development. Thus, it is observed that soil fertilization with DSSC, especially at doses of 23.34 and 46.68 Mg ha-1, is an alternative source to mineral fertilization, as it benefits plant development, has a greater residual effect and increases the stock of Corg in the soil.

CHROMIUM SPECIES IN ORGANIC FERTILIZERS

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Tannery waste is constituted of organic materials of animal origin mixed with inorganic salts. Among them, nutrients are essential to plants and microorganisms, such as nitrogen, calcium, sulfur, phosphorus, magnesium and potassium, enabling their use as fertilizers, as well as their reuse. However, chromium salts are largely used in leather tanning, requiring monitoring its concentrations in fertilizers indispensable. Chrome can be found in various oxidation states, with the most stable species being Cr(III) and Cr(VI). These species significantly differ by their biological and chemical function, highlighting that Cr(III) is essential to humans, while Cr(VI) is highly toxic. For this reason, the Ministry of Agriculture, Livestock and Supply (MAPA) defined the maximum level of Cr(VI) as 2 mg kg-1. Therefore, chromium species determination is imperative. Many speciation analytical techniques are described in the literature, among them electrochemical, atomic spectrometry coupled to liquid chromatography, and UV-Vis spectrophotometry are the most common. Spectrophotometry is one of the most used, since it is of low cost, robust, and is of easy portability. Thus, this research aims the development of a Vis spectrophotometric speciation method for Cr(VI) determination. Extraction of Cr(VI) from the samples was done by adapting the alkaline (NaOH/Na2CO3) method described in the United States Environmental Protection Agency (USEPA) 3060a method. Activated charcoal was used for extract clean up. The analytical characteristics of the method were established, which comply with MAPA's Cr(VI) maximum level. Between the four analyzed samples, only one of the fertilizers complies with the defined limit by MAPA. The method shows to be efficient, robust, low cost and can be used for routine analysis of organic fertilizers.

PRODUCTION OF BIOINPUTS ON FARM - MULTIPLE POSSIBILITIES FOR MANAGING AGRICULTURAL AREAS

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There are several aspects in which Brazil needs to progress in order to increase agricultural productivity. However, the increase in production must be accompanied by environmental conservation. Biofertilizers generated in the agricultural area, known as well as on farm, they are increasingly produced and used in different production systems, but mainly in the agroecological production system. These products are fermented compounds, which act nutritionally for the soil/microorganisms/plant, and act as stimulants in the development of agricultural crops. These compounds act to control diseases and repel insects, and provide, most of the time, a quantity and diversity of microorganisms, in addition to important nutritional factors for the agricultural system. The possibility of these bioinputs being produced in agricultural areas, with local raw material, makes these biofertilizers one of the alternatives to reduce production costs, in addition to these strategies being known as nature-based solutions. There are several raw materials from the agricultural environment that can be used for the development of different biofertilizers, and the main products used are: animal manure, mainly bovine, as they are rich sources of microorganism inoculants, molasses, milk, bran, tubers or crushed plant material, or other food source rich in sugar or protein, which are important sources of energy to feed bacteria or fungi, and other mineral sources, such as ash, ground rocks, and micronutrients to enrich the different types of food. biofertilizer produced on farm. There are several biofertilizers that can be prepared on farm, such as: multiplication of competent microorganisms (MMC) via Solid/Liquid Fermentation, efficient microorganisms (EM), fermented botanicals, among others. The production of different biofertilizers are fermentation processes, which can be produced in the absence of oxygen (anaerobic) or in the presence of oxygen (aerobic). The final product is usually a liquid compound that can be used in the soil, in foliar fertilization, diluted with the irrigation system, or even in seed treatment. Among the benefits of on farm biofertilizers are easy production, as well as easy use, being the same, low-cost social technologies and suppressive action in the control of phytopathogenic fungi and also insect pests in areas of agricultural production, mainly attached to small rural producers.

ANNUAL RYEGRASS GROWTH RESPONSE TO NITROGEN IN A SANDY SOIL AMENDED WITH ACIDIFIED POULTRY LITTER AFTER "QUICK WASH" TREATMENT

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Developed by USDA-ARS scientists, the "Quick Wash" (QW) process selectively extracts phosphorus (P) from manure, producing an acid-washed organic by-product with improved nitrogen (N):P ratio that can be applied based on crop N requirements. Yet, data on the effect of plant response to N application using these acidified by-products as soil amendments are lacking. Here, we evaluated the response of annual ryegrass (Lolium multiflorum Lam.) to N applications and soil inorganic N leaching using raw and acid-washed chicken litter (CHL) and commercial ammonium sulfate (AMS). The soil used in the experiment was a Norfolk loamy sand (Fine, loamy, siliceous, thermic Typic Kandiudults), a typical sandy soil of the Southeastern Coastal Plain, USA. Treatments included raw and acid-washed chicken litter CHL, AMS, and a control (no organic amendment or fertilizer added). The plant response experiment consisted of a pot experiment in a greenhouse. Each amendment was incorporated into the soil before planting the ryegrass at N application rates equivalent to 100, 200, and 400 kg ha-1 on a dry weight basis. The experiment was a randomized complete block design with three replications for 70 days. We harvested ryegrass biomass at 20, 35, 50, and 70 days after planting. Plant biomass from each harvest was oven-dried to a constant weight at 60 ?, finely ground, and analyzed for total N by dry combustion. After the last ryegrass harvest, each pot was leached with 1 L of de-ionized (DI) water and allowed to drain for 24 h before collecting the leachate. Soil sample extracts and leachate were analyzed for ammonium and nitrate by colorimetric analysis. We found no significant differences in ryegrass yield and N uptake between the raw and acidified forms of the CHL amendments. With increasing N application, ryegrass treated with AMS produced 13 – 19% more biomass on average than the raw CHL and 11 – 18% than the acidified CHL. Similarly, N uptake of ryegrass under AMS treatment ranged from 65 – 129 mg N kg-1 dry matter, 50 – 114% greater than the raw and 43 – 103% greater than the acidified CHL. Inorganic N (ammonium plus nitrate) concentration of soil leachate and residual soil inorganic N was greater with AMS application than the raw or acid-washed CHL. However, we found no differences in N leaching between raw and acid-washed CHL. Our results indicated that applying the acid QW by-products can help to substantially reduce N leaching in agricultural soils with additional benefits of reducing soil ammonia emissions and soil P excess with no penalties for crop yield losses in sandy Coastal Plain soils.

ANAEROBIC REACTOR FILLED WITH BAMBOO AS ALTERNATIVE TO TREATMENT OF SWINE MANURE

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Small-scale pig farmers do not always have the financial conditions to invest in traditional waste treatment systems, and they are applied in natura in agricultural soils, which may cause imbalance in soil fertility and/or contamination of the harvested product or water table and springs. The objective of this work was to test an anaerobic reactor filled with bamboo rings of the Balbusa tuldoides species, which have adequate porosity for the formation of microbiological films, are resistant materials, persistent over time, not requiring repeated filling changes, and compare its efficiency with that of a canvas biodigester, over 120-day pig breeding cycle. Bamboo can be easily grown on rural properties, and used grain silos can be used as support for the reactor, reducing biodigester construction costs. Experiment tests were carried out in an experimental farm of the SAA/APTA, Piracicaba, SP, with a capacity for 160 finishing pigs, whose bays were washed daily with jet washer. Raw effluent was collected and transported to homogenization tank, transferred to a sieve with ASII 304 stainless steel screen, 0.5 mm mesh, capacity of 5000 L h-1, 1.0 hp motor, and scraper with speed of 10 rpm, separating the liquid-solid phase, following the sieved effluent to: (i) bamboo reactor composed of 03 tanks filled with bamboo, connected in series, totaling a capacity of 1,200 liters, with retention time of 24 hours; (ii) canvas biodigester measuring 3.0 x 12.0 m, with capacity for 60 m3 of effluents and 30 m3 of biogas, totaling 90 m3, and retention time of 20 days. Periodically to compare the efficiency of the systems, samples of the raw effluent sieved and effluents treated in biodigesters were submitted to physical-chemical, chemical and microbiological analyses. The results indicate that bamboo reactor removes 83% of total solids and COD, and 89% of BOD and C-total, these values are similar to those obtained with the canvas biodigester. Total coliform values were reduced by two logarithmic units in the effluent treated in the bamboo reactors when compared to the canvas biodigester and remained the same for the values of E. coli (104 NPM/100 mL), in addition to the absence of Salmonella sp and viable helminth eggs, proving the efficiency of the bamboo biodigester in 120 test days. However, its efficiency must be evaluated over the long term, as well as its useful life, so that the alternative effluent treatment system can be indicated to small producers.

APPLICATION OF MAGNETIC ADSORBENTS FOR PHOSPHATE REMOVAL FROM SWINE FARMING EFFLUENT

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Phosphorus plays a vital role in supporting life, agricultural activities, and ensuring food security. Human activities have led to the pollution of natural water with high concentrations of phosphate. Therefore, it is essential to recover phosphate to maintain food production and prevent eutrophication. Some materials have been tried for phosphate recovery using adsorption, highlighting ferrous materials, such as hematite, magnetite, ferrihydrite, and ferrites. The present paper used magnesium ferrite ($MgFe_2O_4$) synthesized at 1:1 Mg:Fe molar ratio at 300, 700 and 900°C to recover phosphate from anaerobic biodigester effluent from swine farming. The materials synthesized were characterized by TG/DTG, XRD, SEM/EDS, VSM, Mössbauer Spectroscopic, superficial area BET, and pH(PCZ). The materials were tested as phosphate adsorbents in a solution of known concentration, at different pH and for coexisting ions. Then, the materials were applied to remove phosphate from the effluent. TG analyses indicate complete precursors decomposition after 400°C; furthermore, 700 and 900°C change the material's structure and form new phases. DRX and Mössbauer Spectroscopic indicate hematite (Fe_2O_3) and magnesium ferrite ($MgFe_2O_4$) for samples MgFe700 and MgFe900. VSM and Mössbauer's Spectroscopic parameters show a superparamagnetic material formed. SEM shows micro particles agglomerate because de superparamagnetic behavior, and BET indicates no porous material formed for MgFe700 and MgFe900. The pH(PCZ) results show that at pH>7 the material's surface is dominated by an excess negative charge making it difficult for PO_4^{-3} adsorption. The adsorption results for all synthesized samples show a trend towards an increase in adsorption capacity with increasing calcination temperature and formation of magnesium ferrite. The MgFe and MgFe300 samples showed phosphate removal values ??equal to 11.4 mg.g-1 and 13.1 mg.g-1, respectively. These results may be linked to soluble Mg^{+2} and Fe^{+3} in the samples, which lead to precipitation, in addition to hematite with adsorption processes. Samples MgFe700 and MgFe900 presented results of 16.8 mg.g-1 and 19.7 mg.g-1. The pH test indicates pH 7 for better phosphate removal, reinforcing pH(PCZ) results. Adsorbents MgFe700 and MgFe900 showed an adsorption capacity of 28.5 mg.g-1 at pH 7 and 24.3 mg.g-1 at pH 5, respectively. The coexisting ions test suggests that in the presence of Cl^-, NO_3^- and HCO_3^- the phosphate removal increase by 20%, 17% and 3%, respectively, and in the presence of SO_4^{2-} and CO_3^{2-}, decrease by 12% and 8% for MgFe700 respectively. In the adsorbent MgFe900, the presence of Cl^-, NO_3^- and HCO_3^- the phosphate removal increases by 3%, 25% and 25%, respectively; however, SO_4^{2-} and CO_3^{2-} coexisting PO_4^{3-} removal decrease by 7% and 33%. For the phosphate recovery from anaerobic biodigester effluent, MgFe700 removed 56%, and MgFe900 removed 54% of the phosphate amount. The results show that materials can be applied in different conditions, showing satisfactory phosphate removal. Effluent tests showed that the materials could be used for phosphate recovery from anaerobic biodigester effluent.

EFFECTS OF THE APPLICATION OF MICROALGAE OBTAINED FROM HYDROPONIC EFFLUENTS AS BIOSTIMULANT POTENTIAL IN SEED GERMINATION

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The agrarian transformation has had a positive impact on increasing food production, agricultural land, irrigation, and soils. However, this practice has led to serious nutritional imbalances, groundwater pollution, and considerable greenhouse gas emissions. Therefore, it is imperative to seek more sustainable alternatives to overcome these limitations. Biofertilizers and biostimulants fit into this context as a viable, healthy, and pollution-free option, and are currently considered the best substitute for chemical fertilizers. Among the various types of bioinputs, microorganism-based formulations, including microalgae, have been growing substantially due to their excellent ability to increase soil fertility, improve nutrient quality, and the productivity of different crops. In parallel, the microalgae biomass grown in effluents has the potential to be applied in sustainable technological routes to obtain bioproducts. This biomass is rich in organic matter and nutrients, so it can be widely applied as a biostimulant and biofertilizer for different types of soils and crops. In this sense, the objective of this study was to evaluate the influence of different concentrations of microalgae consortium (Chlorophytes and Cyanobacteria) obtained from a hydroponic effluent on the germination of radish seeds (Raphanus sativus). Briefly, the microalgae consortium was diluted in suspensions containing the following concentrations: (T1) 5%, (T2) 10%, (T3) 15%, and (T4) 25%, resulting in treatment equivalent to concentrations of 0.105 g L-1, 0.210 g L-1, 0.315 g L-1, and 0.525 g L-1, respectively. In addition, onecontrol treatment (T0) with only distilled water was also added to Petri dishes containing cotton. Five replicates of 10 seeds were prepared and the plates were kept in a germination chamber (Tecnal, TE 402) at a constant temperature (25°C), controlled photoperiod of 12h:12h (light/dark) with continuous aeration. The number of germinated seeds was counted daily until reaching a total of 96 hours of germination, where at the end the size reached by the seedlings was also verified. Recorded data were analyzed using Statistica 10.0 software (StatSoft, Tulsa, OK, USA) to test differences between treatments by analysis of variance (one-way ANOVA) and Tukey's test. The final results of the germination test indicate that treatments (T1) and (T2) were superior to the control test (T0), with a total mean of 96, 90, and 86%, respectively, of germinated seeds at the end of 96 hours. Furthermore, the average growth of the seedling for the treatment (T1) was 20% higher when compared to the control test. In this sense, the results indicate that the amount and type of substrate used directly influence the quality of germination of Raphanus sativus seeds. In particular, microalgae-derived bioinputs, when applied in low doses to the seed are capable of positively regulating and improving the physiological processes of the seedling.

ANALYSIS OF THE CHARACTERISTICS OF BIOCHAR FROM CYMBOPOGON CITRATUS FOR AGRONOMIC USE

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The generation of agro-industrial waste is a reality for several segments of the production chains related to agriculture and food production. Millions of tons of waste are estimated to be discarded annually, consisting of fruit peel, bagasse, cultural remains, straw, bark, and wood remains, among others. The inadequate disposal of these residues promotes an environmental liability capable of contaminating soil and water, serving as vectors of diseases, and increasing the emission of greenhouse gases. The essential oil industry, from oil extraction, produces a large amount of residual biomass. Thermochemical conversion of lignocellulosic residues is a technique that enables the mitigation of impacts generated by inadequate disposal of residues by obtaining products with potential for use in different areas. The pyrolysis of this residual biomass allows for obtaining biochar, a carbonaceous material with a stable structure, mainly composed of aromatic carbon chains. Several studies point to the potential agronomic use of biochar from different sources. Thus, the present work aimed to analyze the characteristics of the biochar obtained by the pyrolysis of Cymbopogon citratus biomass through the analysis of nutritional elements for the soil, the parameters of pH, electrical conductivity, FTIR (infrared spectroscopy by Fourier transform), SEM (scanning electron microscopy) and heavy metal contents (As, Cd, Pb, Cu, Cr, Hg, Mo, Ni and Zn). C. citratus biochar was obtained through pyrolysis at 450 °C of the residual biomass derived from essential oil extraction. The analysis of the nutritional elements showed the presence of potassium (44.5 g·kg-1), followed by calcium (12.1 g·kg-1), nitrogen (11.9 g·kg-1), and phosphorus (5.2 g·kg-1). Such contents allow biochar to increase these nutrients and soil fertility when incorporated into it. With a pH of 10.04 and electrical conductivity of 5.8 dS·m-1, C. citratus biochar has characteristics that make it a potential product for correcting acidic soils and increasing the cation exchange capacity (CTC). The FTIR results demonstrated the presence of free and structural hydroxyl groups associated with cellulose and hemicellulose, in addition to amines (3,000 – 2,900 cm-1). Bands related to functional groups such as nitrogenous compounds, aromatic chains, carboxylic acids, phenols, alcohols, sulfates, and esters were also observed (2,150 – 1,000 cm-1). The presence of these chemical groups allows for better interaction with different soil components. Through SEM analysis, micropores in the material with an average diameter of 1.32 µm were observed, as well as the visualization of characteristic structures of the source material. This gives C. citratus biochar a greater water retention capacity and ease of adsorption in the soil. The verified parameters for heavy metals were compared to the maximum concentration limits established by CONAMA resolution 375/2006 for agricultural use, and it was observed that they were all below the maximum limit for heavy metals, which makes the use of this biochar viable for agricultural purposes. The characterization of C. citratus biochar demonstrated that this material presents an effective possibility of agronomic use as a soil corrective, fertilizer, and/or soil conditioner.

EFFECTS OF APPLYING BIOCHAR FROM URBAN SOLID WASTE ON AVENA SATIVA SEED GERMINATION

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The environmental problems arising from the inadequate disposal of solid urban waste (USW) cause worldwide impacts, with a growing demand for new technologies aimed at the sustainable use of uSW. Among the different uSW, domestic, company, and agro-industrial waste are included. In agriculture, the need for new environmentally sustainable production systems creates a favorable environment for the emergence of techniques such as thermochemical conversion of waste. Using these techniques results in obtaining products with agronomic potential, aiming to mitigate the impacts of production on the environment. Pyrolysis has proved an interesting process for treating MSW, getting products with potential applications in different areas. In line with the sustainable development assumptions of the UN's 2030 Agenda, using USW biochar in the soil can enhance its effects on agricultural soils from carbon fixation and remediation of these soils. Biochar has a stable structure, composed chiefly of aromatic carbon, with reactive functional groups that promote interaction between biochar and soil components, optimizing plant development. In this way, the present work aimed to evaluate the effect of USW biochar on the germination of Avena sativa seeds to verify the possibility of use in the soil or substrate without prejudice to the emergence phase of the plants. A completely randomized experiment was conducted with four repetitions of 50 seeds per treatment (200 seeds per treatment) according to the methodology described by the Seed Analysis Rule (RAS, 2009). The treatments employed were: T1 (control without biochar), T2 (germitest paper containing 5 wt.% biochar), T3 (germitest paper containing 7.5 wt.% biochar), T4 (germitest paper containing 10 wt.% biochar), and T5 (germitest paper containing 20 wt.% biochar). The results underwent analysis of variance (ANOVA), and statistically significant differences between the treatments means were compared by Tukey's test at a 5 % error probability using the statistical software AgroEstat. There was no statistical difference in the germination of Avena sativa seeds between the treatments. The average germination presented was 98.1 %, above the minimum percentage of 80 % established for commercialization according to the normative instruction of the Ministry of Agriculture, Livestock and Supply (MAPA). The germination speed index (GSI) was observed to be higher in the treatments with USW biochar treatments, being statistically higher in the treatment where 10 wt.% USW biochar was used. The evaluation of the effects of MSW biochar application on Avena sativa seeds showed that it did not inhibit seed germination.

MONITORING AND EVALUATION OF A SWINE WASTEWATER TREATMENT SYSTEM FOR AGRICULTURAL REUSE

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Swine wastewater can be used in agricultural irrigation providing water and nutrients to plants, provided that its quality does not cause contamination to the soil-water-plant systems. This study monitored and evaluated four series treatment systems for the removal of organic load and nutrients/contaminants, in a pilot wastewater treatment system in an experimental farm with capacity of 160 finishing pigs at APTA/Piracicaba, SP. Animals' bays were washed daily with water jet and the raw effluent to the 3,000-liter homogenization tank, and then transferred to stainless-steel sieve with a 0.5 mm mesh through a vortex pump. Solids retained in the sieve were sent to the composting process, and the liquid phase was transferred to a canvas biodigester with capacity of 60 m3, of which 60 m3 for liquid and 30 m3 for gas phase, and detention time of 20 days. Anaerobic effluent was sent to an aerobic treatment system with a capacity of 3,000 L, external structure in fiberglass, piping in rigid PVC, aeration using 7.5 hp radial compressor and 03 fine bubble diffusers with individual air supply of 120 L min-1. After aerobic treatment the effluent was sent to the physical-chemical process, composed of a flocculation reactor, metering pumps, floto-decanter tank and sludge remover, using for each 2,000 liters, 9.0 liters of polyaluminum chloride and 37.5 g of cationic polymer, quantities these obtained in flocculation test, and the sludge drained into drying beds was destined for the composting process. Effluent samples collected weekly in each phase of treatment for analysis physical-chemical, chemical and microbiological analyses. Organic and nutrients removals for the parameters COD, BOD, C-total, N-Kjeldhal, N-NH4+ and P-total were, respectively: 31%, 27%, 59.6%, 18.6%; 19% and 16% for the sieving process; 85.2%, 78.5%, 83.2%, 36.6%, 14.6% and 67.5% for anaerobic treatment; 41.2%, 98.1%, 37.7%, 12.7%, 0.7% and 81.6% for aerobic treatment, and 99.7%, 77.3%, 52.0%, 0.5%, 28.9%, 85.2% for physical-chemical process. Global removals in the system were around 97.0% for COD, BOD and C-total, and 96% for P-total, which must have remained to the sieve solids and precipitated to sewages in the canvas biodigester, aerobic reactor, physical-chemical process. N-NH4+ removals were 35.6%, with a maximum value of 8.7 mg L-1 of N-NO3-, in accordance with agricultural reuse regulation. Sodium was the element that remained in the system and of greatest concern, whose final contents were around 360-600 mg L-1, well above the value of 39 mg L-1, established by the São Paulo State Environmental Agency for agricultural reuse, reflecting in high values of electrical conductivity and result of the high contents of the element in animal feed. Thus, the irrigation depth and periodicity should consider the levels of sodium in the effluent so that it does not cause to soil salinization, and/or loss of groundwater potability in case of its leaching.

ELECTRO-PRECIPITATION OF K-STRUVITE IN BIOLOGICAL WASTEWATER TREATMENT EFFLUENT

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The decline of terrestrial resources, rising ore costs, and increasing pollution demand wastewater recycling in the circular economy context. Swine wastewater is characterized by the presence of nitrogen (N), phosphorus (P), and potassium (K), of which P and K can be recovered as K-struvite crystals. Combining two or more processes is necessary for high nutrient removal and recovery efficiency. Among these technologies, the electrochemical process is considered promising due to its high removal efficiency of K and P in solid form. This study evaluated the current density (DC) and hydraulic detention time (HDT) in a continuous-flow electro-precipitation reactor using magnesium electrodes. The wastewater used for K-struvite production was collected from the outlet of the N module, where the nitrification/denitrification process of the SISTRATES® system, designed for swine waste treatment, is implemented on a farm located in Videira, Santa Catarina, Brazil (27°02'38.8?S 51°05'35.7?W). The electrochemical system consisted of a continuous-flow electrochemical reactor made of acrylic. The experiments were conducted continuously at room temperature (23°C), in an open reactor with a useful volume of 1.8 L. The magnesium electrodes had an area of 4,000 mm2 and dimensions of 130 mm in height x 70 mm in width, made of AZ91 alloy (donated by RIMA Industrial). The evaluated DC of 0.1 and 0.3 A was controlled using a power supply connected to a direct current (DC) electric source (DC Power Supply FA-3005 Intrutherm). The two electrodes (1 cathode and 1 anode) were vertically installed with a constant distance of 2 cm between them during electro-precipitation. A peristaltic pump (Masterflex L/S) was used to provide flow rates of 15 and 30 mL.min-1 to the electrochemical reactor, generating HDTs of 120 min and 60 min, respectively. Samples were collected at 0, 1, 2, 3, 4, 5, and 6 hours. The analytical determinations performed included potassium (mg.L-1), magnesium (mg.L-1), total phosphorus (mg.L-1), calcium (mg.L-1), and pH. The effect of current density and HDT on the recovery of nutrients by electrochemical precipitation was investigated. Under the conditions of DC of 0.1 A and HDT of 60 and 120 min, and DC of 0.3 A and HDT of 60 and 120 min, it was observed that the pH values increased throughout the process under all conditions, with minimum values of pH 7.42 and maximum values of pH 10.2. When comparing the phosphorus (36%), potassium (10%), and calcium (13%) removal values, there is a correlation between the increase in pH and the enhancement of the removal of these parameters, with the condition that showed the best removal having the highest DC (0.3 A) and the longest HDT (120 min). The magnesium concentration increased in all experiments, with values ranging from 79 to 217 mg.L-1. Overall, our results show that electrochemical crystallization is promising for the recovery of K-struvite fertilizers.

RESPIROMETRY TEST AS A TOOL TO PREDICT PROPORTIONS OF ORGANIC MUNICIPAL WASTES IN COMPOST PILES

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Partially stabilized organic waste, such as sewage and agro-industrial sludges and tree pruning, is an option for composting of the large volume generated in urban centers. However, these materials may present recalcitrance in decomposition, either by previous decomposition in the sewage sludge, or by the presence of material with lignin in the tree pruning, being necessary to obtain its adequate proportion so that high rates and speeds of decomposition occur. Respirometry test was used as a tool to predict the best proportion of materials for the composting process of the sewage sludge from an aerobic treatment process (activated sludge) and tree pruning generated in the city of Piracicaba, SP. Also, the residues carbon determinations were made with sample heating under reflux (C-total) and no sample heating (C-available), and the results used to compose to control treatments in the respirometry test. Respirometry test was carried out in randomized test with 3 replicates, for a period of 126 days, and the following treatments: T1: sewage sludge + sugar as C source, using total-C and mixture with C/N ratio of 30:1; T2: sewage sludge + sugar as C source, using available-C and mixture with C/N ratio of 30:1; T3: sewage sludge + 70% tree pruning; and T4, T5, T6, T7, T8 with increasing amounts of sludge up to 80% and 20% tree pruning. Released CO2 was captured by of a sodium hydroxide standard solution and daily determination by electrical conductivity. Trial data were adjusted using a first-order chemical kinetic equation, estimating the decomposition rate and speed. Composting piles were built with a total volume of 10 tons, turned over and irrigated according to temperature and humidity monitoring, with mixtures of 40-60% sludge, and C/N ratios ranging from 23/1 to 30/1. C-total content were 30 to 70% higher than the C- available for tree pruning and sludge, indicating the recalcitrant nature of sewage sludge. However, in the decomposition test, T2 treatment (C- available) presented a decomposition rate only 0.82 % rate than the T1, indicating that C-total analysis performed by routine laboratories can be used for calculation of compost piles. It was observed a proportional increase in the C-degraded rate with the increase in the percentage of sewage sludge in the mixtures. However, decomposition rate of mixtures up to 60% sludge were similar to those with 20-30% of sludge. Organic composts produced in the field presented carbon and nitrogen contents above 15% and 0.5%, respectively, C/N ratio less than 20:1, and CTC values greater than 80mmolc kg-1. There was a reduction of total and fecal coliforms of 1.2 x 107 and 6.9 x 105 NMP/g ST sludge, respectively, for values in the range of 103 in the organic composts, as well as the absence of Salmonella sp, and reductions of around 90% in viable helminth eggs, classifying the materials for registration and commercialization by current agricultural legislation.

K-STRUVITE PRECIPITATION AT DIFFERENT PH AND TEMPERATURES FOR POTASSIUM AND PHOSPHORUS RECOVERY

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The recovery of nutrients from swine wastewater and their recycling as fertilizers is a challenging opportunity to the reduce the demand from mineral fertilizers. The intensification of swine farming in confined feeding operations has led to increased generation of wastewater rich in nutrients such as phosphorus (P) and potassium (K). P and K from mineral resources are widely used, mainly as chemical fertilizers, but these resources are exhaustible. Therefore, it is interesting to recover P and K to avoid environmental problems and also to add value to the effluents. The production of K-struvite, a mineral compound containing P, K and magnesium (Mg) seems to be a promising alternative within the circular economy concept. Therefore, the objective of this work was to evaluate the recovery of K and P from swine wastewater through chemical precipitation of K-struvite.

For this purpose, the effluent from nitrogen removal module from SISTRATES® (a Portuguese acronym for swine effluent treatment system) was used. After the effluent chemical characterization, laboratory tests were carried out to evaluate the production of K-struvite and P and K recovery efficiency. To optimize the best K-struvite precipitation condition, a 22 factorial design with central point was applied to understand how the pH and temperature influence the K-struvite formation process. The experiments were performed in random order to avoid systematic errors at batch and using 1 L of effluent for each test. A stirring time and speed of 10 min and 200 rpm, respectively, were used and the pH was adjusted by adding NaOH 4M. After the reaction time under stirring, the samples were transferred to Imhoff cones and left for 24 h for complete reaction and seetling. Then, the supernatant and precipitate fraction were separately collected and analyzed for P and K.

It was possible to observe a P removal efficiency higher than 90% in most of the tests, and a K K removal between 5% and 27%. To evaluate the production of K-struvite, the molar ratios of K:P:Mg contained in the precipitates were observed in relation to the molar ratios in the effluent used for the study. In this way, the best condition observed was at pH 10, with no significant difference between the different temperature ranges. At pH 10 and 20ºC, the molar ratios in the sludge were 2.3:1:0.6. At pH 11, the molar ratios were 1.5:1.0:1.5, showing that in addition to the precipitation of K-struvite (1.0:1.0:1.0), other compounds possibly precipitated, as magnesium hydroxide.

The initial pH of the effluent was 6.77, after the addition of NaOH it was possible to verify that at higher pH, the volume of sludge inscreaded, corroborating with greater removals of K, P and Ca of the effluent, regardless of temperature. However, for K-struvite precipitation, the best pH range was between 10 and 11. In the other values tested, it was possible to observe the precipitation of other compounds, as mentioned. Thus, the production of K-Struvite is a promising alternative for the recovery of K and P from swine wastewater.

COMPARATIVE STUDY OF AGROINDUSTRIAL WASTES ADDITION TO TWO SOILS FOR IMPROVING WATER HOLDING CAPACITY

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Organic and inorganic amendments are commonly added to degraded soils, improving physical, chemical and biological characteristics. Diatomite earth mainly contains SiO2 (86.3%), other oxides and micronutrients (39 trace elements) and it is capable of absorbing up to 2.5 times its weight, due to its high hygroscopic capacity. Due to its high silicon content, it improves the ability to retain water in plant tissues and favors root development, increasing the assimilation and distribution capacity of minerals. Perlite, which is added to increase the number of pores in the substrate, to improve drainage and aeration, and is used as a substitute for sand. Its main advantage is its light weight, close to 96 g/L compared to 1600 g/L for sand. Perlite is a silicon mineral that when it expands due to the effect of temperature keeps a large volume of air locked up. Perlite is chemically inert, has a near neutral pH and absorbs 3 to 4 times its weight in water and is widely used in nursery substrates. Biochar has a great capacity to water retention and contains many elements and organic material adequate for crops production. We evaluated the addition of 0.5% each of diatomite earth (D) from brewery production, perlite (P) from agar production industry and biochar (B) from a biomass boiler as amendment to improve water holding capacity (WHC) in two soils: Sandy soil (S1) and Trumao soil (S2). Soils were amended with different combination of the agroindustrial wastes and were compared to commercial diatomite, perlite and peat (Pe). Besides, a phytotoxicity assay was made to evaluate the effect of these residual materials (1%) on Lolium perenne seeds germination parameters. The main results showed that WHC of Sandy soil without amendment was low (30-32%) compared to Trumao soil (60-63%). The WHC of both soils increased by the addition of the agroindustrial wastes, being the highest increment in Sandy soil (52%) when the combination of P-D-B-Pe substrates was added. Respect to Trumao Soil, the highest increment of WHC (40%) was obtained when the combination of P-D-Pe was added. The germination index of L. perenne seeds was >100% in Sandy soil with some combination of substrates (P-B-Pe, B-Pe and P-B). In Trumao soil, the germination Index remained below 100%. No significant differences ($p<0.05$) were found when perlite and diatomite from commercial origin were applied to both soils instead of these waste materials utilizations coming from agar and brewery industries, respectively. In general, the application of the agroindustrial residues used in this study improved the water holding capacity in both soils and no phytotoxic effects were observed in the seeds of Lolium perenne.

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AGRONOMIC EFFICIENCY OF ANIMAL RESIDUES BASED PHOSPHORUS FERTILIZER

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The high demand for phosphate fertilisers and the external dependence on these inputs highlight the need to develop strategies to meet the phosphorus (P)
eficiency of Brazilian soils. The country has a great potential for exploitation considering the large volume of agricultural waste generated in this sector. The use of fertilisers produced from the pyrolysis of bovine bones (Bone Char) and swine effluent (digestate) is a sustainable alternative destination for these residues. The practice promotes circular energy and enables the supply of P to plants. This work aimed to evaluate the dry matter production of maize the accumulation of P under the influence of fertilisation with agricultural residues. The experiment was conducted in a greenhouse, using a completely randomised design, with four treatments and four replications. The treatments were composed of agricultural residues (Bone Char and digestate), in addition to the reference fertiliser triple superphosphate (STP) and the control treatment (without P). The treatments were incorporated into the soil in full volume before the first planting, at a P dose of 160 mg kg-1 of soil. The experimental units were formed by pots with 2 kg of Red Latosol and a maize plant (Zea mays L., hybrid AG 8740 PRO3). Two crop of 45 days were carried out. After the experimental period, the shot of the plants was collected, conditioned in an oven at 65°C until complete drying and the dry mass of the aerial part was measured. P extraction was performed by nitroperchloric digestion and determination by the colorimetric method using UV/visible spectrophotometry. Shapiro Wilk and Bartlett's test were used to assess normality of residuals and homoscedasticity of variances, respectively. Means were compared using Scott Knott's mean test.
In the first crop, agricultural residues showed a positive response in the production of aboveground dry matter. "Bone Char" had a higher production equivalent to the reference treatment (STP), followed by "digestate". In the accumulated dry matter, all fertilization treatments were superior to the control treatment. "Bone Char" showed results similar to STP. The highest accumulation of P by maize in the first cultivation was observed with the application of "Bonechar", resulting in the same amount of P as STP. In the P accumulation, combining the two cultivations, "Bone Char" provided a greater accumulation of P in the plants. Fertilization with "Bone Char" can result in an agronomic performance equivalent to soluble fertilizer (STP). These agricultural residues can be a promising alternative to supply the deficiency of P in tropical soils and meet the demands of crops with high demand for this nutrient, such as maize.

EVALUATION OF THE COST BENEFIT RATIO OF USING PIG SLURRY AS AN ORGANIC FERTILIZER IN THE MUNICIPALITY OF PRESIDENTE CASTELLO BRANCO, SC

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The western region of Santa Catarina stands out for the intensive production of animals, especially pigs, broiler chickens and dairy cattle. In this territory, the transport service and disposal of pig slurry is a great challenge, since most rural properties do not have enough agricultural area to use this material as fertilizer, making it necessary to transport it to other places. Despite the presence of nutrients with fertilizing power in the pig slurry, depending on the distance it will be transported, the cost-benefit ratio of its use is not always positive. In this context, the objective of this article was to evaluate the cost-benefit ratio (CBR) of the pig slurry distribution service, taking as reference data from the tractor fleet of the Municipal Secretariat of Agriculture and Environment (SMAMA) from Presidente Castello Branco (SC), a small municipality that well represents the reality of animal production in the region. In order to calculate the costs of applying pig slurry, the market prices per hour/tractor machine (hM) in the regional market, provided by the CEPA Institute, in the period 2013-2022 (INFOAGRO) were used as a reference. In turn, the benefit was calculated from the average amount of 5.21 kg of NPK per cubic meter of the pig slurry (2.1% DM), multiplied by the average price of the mineral equivalent. The monitoring and analysis of data from the SMAMA fleet revealed that the predominant situation is the transport of waste using tractors coupled to tanks with an average capacity of 4m3, which can carry out three loads of waste per hour, totaling an average volume of 12m3 of waste per hour. Considering the historical average of the fertilizer value and the hourly cost of the tractor machine over the last ten years, period 2013-2022, it appears that the cost-benefit ratio is only positive from a minimum transport of 7.2m3 of the pig slurry per hour machine, a condition that is not met in 30% of the total the services carried out by the SMAMA fleet. In turn, in the monitoring period of the SMAMA fleet (2020 to 2022), it was found that in the three years the BCR was positive for the use of the pig slurrye (CBR>ZERO), with the least favorable year being 2020, when the minimum volume of waste to be transported needed to be 6.5m3 / hM. In turn, the year 2022 was the most favorable, as the transport of 3.2m3 / hM would be enough for the CBR to be positive. Finally, in monetary terms, considering that the fleet of SMAMA machines annually transports an average of 33,020m 3 , an estimated annual benefit is obtained, resulting from the reduction in the purchase of mineral fertilizer, of the order of $90,000.00 Despite this positive economic relationship in the use of the pig slurry as an organic fertilizer, it is necessary to better qualify this policy, since aspects related to the quality of the manure and the operational control of the fleet of machines are not being properly observed.

Promoter

Co-promoter

Host

Support

Support

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