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Chicken Manure Valorization through Anaerobic Digestion: Advances in Ammonia Mitigation and Biogas Production Enhancement

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Abstract: ***The world demands a huge amount of energy for sustainable development and daily needs. Implementing waste to wealth strategies and recycle based economy models contributing to reduce biomass waste and value addition. The chicken manure is an essential source of organics, ammonia - nitrogen, pathogens, and microorganisms degrading bacteria, by using Anaerobic Digestion method chicken manure can be converted into renewable energy such as biogas. The bioconversion of chicken manure into biogas by Anaerobic digestion with addressing inhibiting factors, enhance digestion and valorization. The anaerobic digestion can be improved by various approaches include pretreatment of chicken manure by physical, chemical, biological processes and co-digestion of chicken manure with organic substrate, lignocellulose material, micro algae; through additives like zeolite, activated carbon, biochar, carbon nanotubes, magnetite to improve microbial community. The current review on biogas production from chicken manure suggests that the technology combined with achievement and Interpretation that provide an review of the different approaches to remove ammonia from AD process to achieve high yield of biogas. Moreover, this review provides zero emission for waste disposal and value addition of the waste for renewable green energy production.***

Keywords: Chicken manure, Anerobic digestion, Ammonia, Methane

I. INTRODUCTION

Discovering Strategies approaches to produce energy from waste material represents one of the key challenges of current society, because of rising worldwide energy need (Calise et al., 2021). The large majority of the global energy needs are covered by fossil fuels, but their greenhouse gas emissions led to a serious ecological imbalance risk. The waste-to-energy and resources recovery systems are strongly related to regenerative economic model, designed to minimize waste via resources regeneration and reuse (Tawfik et al., 2023). A significant volume of chicken manure is generated from accelerated growth of chicken farms (Rubežius et al., 2020). One of the most frequently used organic waste produced worldwide is farm manure, and incorrect disposal may have negative effects on the ecosystem (Tawfik et al., 2023b). Their potential contribution to the global energy system is enhanced by increased methane output from these sources (Al- Zoubi et al., 2024). Chicken manure, as one of the primary organic waste materials, requires effective utilization. The methanogenic digestion process of organic waste identified as a optimal choice for optimizing reduction of waste and biomass-to-energy conversion (Ziganshina & Ziganshin, 2022). Microbial degradation under oxygen-free conditions for breakdown of organic feedstock (Malolan et al., 2021). Chicken manure contains high amounts of organic matter such as ammonia, nitrogen, pathogens, and various microorganisms, including microbes capable of degrading organic compounds. Due to its high total solid content and excellent biodpathogenss a suitable feedstock for bioenergy production systems, particularly biogas production technology (Tawfik et al., 2023b). Despite ammonia inhibition being the main problem in the anaerobic digestion of chicken manure, which has a high content of organic nitrogen. Numerous strategies have been employed to mitigate or eliminate the inhibitory effects of ammonium. These encompass the pre-treatment of chicken manure, co-digestion, dilution, and the enhancement of anaerobic digestion to increase biogas production (Zhu et al., 2024). Over past decades, multiple techniques have been investigated for ammonia recovery from anaerobic digestion of mixed sludge. These methods include membrane distillation, leach bed coupled with biochar filter, ultrafiltration membrane (Rivera et al., 2025). Some additives, like biochar, hydrochar, carbon nanotubes, magnetite, granular activated carbon, and conductive materials, can also make anaerobic digestion work better and speed up the direct interspecies electron transfer process.

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Significant consideration has been given in the reviews to investigating the characteristics of chicken manure, various pretreatment processes, and strategies to enhance the anaerobic digestion process. Furthermore, this review provides a comprehensive examination of suitable experimental methods for managing organic manure and evaluates its feasibility and applicability to enhance environmental and economic advantages. It specifically highlights the use of chicken manure as a substrate in anaerobic digestion technology, while also identifying current limitations and suggesting potential solutions to enhance process efficiency.

II. CHICKEN MANURE CHARACTERISTICS

Chicken manure has received considerable attention as a substrate for biogas production because of its rich organic and nutrient composition. It is frequently highlighted in literature: its low carbon-to-nitrogen ratio. Compared to optimal range required for stable anaerobic digestion, chicken manure contains relatively more nitrogen than carbon. This imbalance accelerates nitrogen release during digestion and increases the likelihood of ammonia-related inhibition, particularly when chicken manure is used as the sole substrate (Konkol et al., 2023). Chicken manure contains high nutrient valuable for plants. It acts as source of the dissemination of Anti-microbial resistance in the soil. Untreated chicken manure is treated for input for green house emission and reduces AMR bacteria. Due to the presence of higher level of nitrogen results in generating toxic free ammonia during anaerobic digestion (Atanasova et al., 2025). Chicken manure is abundant in organic matter and vital nutrients including nitrogen (N), phosphorus (P), and potassium (K), which are crucial for plant development. This makes CM an excellent raw material for producing organic fertilizers. Raw CM can contain harmful microorganisms and pathogens, posing environmental and health risks. It often emits a strong odour, which is a concern during handling and storage. Drying CM effectively removes water, reduces fermentation, and minimizes pathogen proliferation. Drying also helps control odour, reduce environmental risks, and enhance storage stability (X. Li et al., 2025)

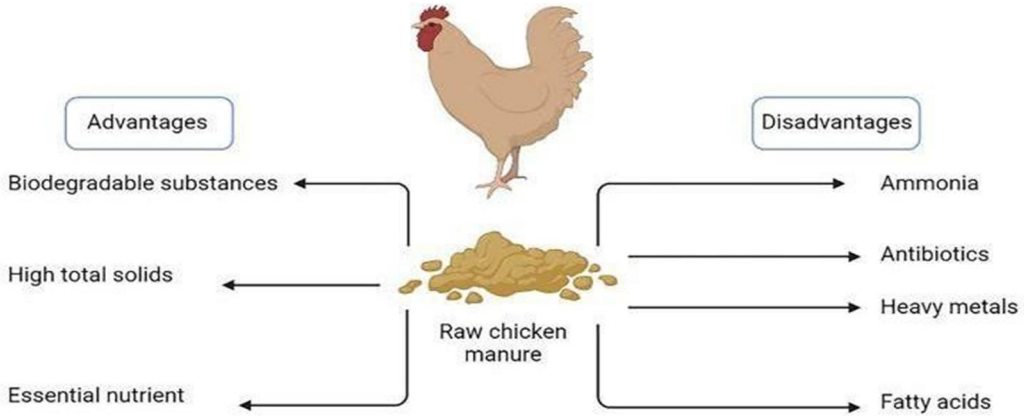


Figure 1. Chicken manure is an available source which contains nutrients total as well as adverse elements to induce anaerobic digestion. From the review (Tawfik et al., 2023b).

III. ANAEROBIC DIGESTION

Chicken manure is organically abundant, management and stabilization of manure efficiently carried out by anaerobic digestion and Co-digestion**.** In anaerobic digestion, biogas is produced when the microorganism's breakdown into organic matter under the absence of oxygen (Abubakar et al., 2022). It is an important process for proper degradation when balancing the organic matter along the biogas production from chicken manure. Anaerobic digestion is a eco-friendly solution for livestock derived biomass management technology (Jurgutis et al., 2020). The utilization of organic matter from the substrate with high content of undigested protein and uric acid results in process fluctuations due to an increase in ammonium and free ammonia. Anaerobic digestion of feedstock and complex microbial process that involves in anaerobic biodegradation pathways, divided into four stages: hydrolysis, acidogenesis, acetogenesis and Methanogenesis (Ziganshina & Ziganshin, 2022). During hydrolysis protein, carbohydrates, and lipids in organic wastes are decomposed into amino acids, simple sugars, and fatty acids by microorganisms such as bacteria and fungi. The products from the hydrolysis are converted by acidogensis bacteria transformed into organic acids, alcohols, ketones, acetates, carbon dioxide and hydrogen. Fatty acids and alcohols are metabolized by acetogenic bacteria into acetate, hydrogen, carbon dioxide. The acetate and integrated hydrogen and carbon dioxide are processed by methanogenic archaea into methane. The consolidated biogas is approximately 60% of methane and 38% of CO_2 (Franke-Whittle et al., 2014).

Hydrolysis and acidogenesis bacteria have high ammonia resistant than methanogens, the primary reason for addition of organic acids leads to high ammonia levels. The ammonia nitrogen concentration has significant effect on acetogenesis activity. Methanogenesis process is a strategy that evaluates methane production from the both cleavage of acetate and hydrogen- dependent CO_2 conversion (Song et al., 2023). Efficient anaerobic digestion is achieved through an proper TAN control and stable AD conditions. One

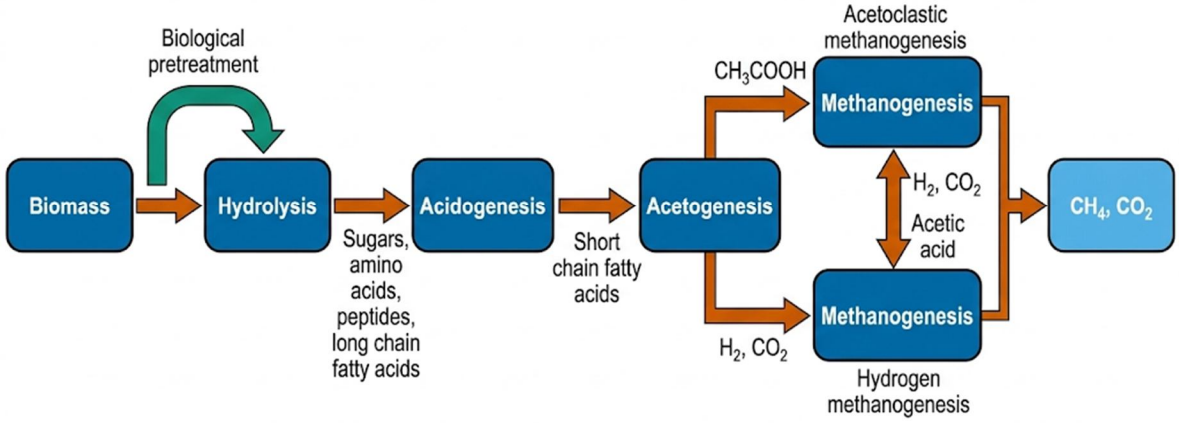


Figure 2. Metabolic pathway of organic matter during anaerobic digestion. From the review of (Olatunji et al., 2021)

of the major methods to analyze the AD functional stability of intermediate metabolism occurs in liquid phase under TAN concentration. AD stability can be assessed by monitoring methane, pH, alkalinity and VFA . The TAN increases concentration reached at 1600mg/L after that gradually decreased .The pH increased from 7 to 8.2 highly significant correlations with TAN concentration. When the optimal TAN concentration increases the pH increase sharply. The appropriate range of pH for AD is 6.5 to 8.Alkalinity is indicative of the buffering potential in anaerobic digestion reflects the stable or unstable alkalinity ratio or VFA exhibited a comparable behaviour as the pH value. When the TAN concentration is exceeding the limits (>1600mg/L) it leads to methane decreases due to microbes cannot be worked properly which facilitates ammonia inhibition (F. Wang et al., 2019).

IV. ENHANCEMENT OF CHICKEN MANURE ANAEROBIC DIGESTION

A. Pretreatment

1) Biological Pretreatment Using Bacterial Strains To Enhance Biogas Yield

Biological pretreatment of poultry waste using selected bacterial strains has been reported as an effective method to enhance anaerobic digestion performance and biogas yield. Pretreatment employing bacterial consortia dominated by hydrolytic and fermentative bacteria such as Bacillus spp., Pseudomonas spp., and related metabolically active microorganisms improves the initial hydrolysis of complex organic matter present in poultry waste. These bacterial strains produce extracellular enzymes, including proteases, lipases, and cellulolytic enzymes, which accelerate the breakdown of proteins, fats, and other complex polymers into simpler soluble compounds.

Enhanced solubilization of organic matter facilitates improved substrate availability for acidogenic and methanogenic microorganisms, resulting in increased biogas and methane production during subsequent anaerobic digestion. In addition, biological pretreatment has been shown to improve process stability by promoting balanced microbial activity and reducing limitations associated with slow hydrolysis. Overall, the use of selected bacterial strains as a pretreatment method represents an environmentally friendly and effective strategy to optimize biogas yield from poultry waste (Cybulska et al., 2021).

2) Biological Pretreatment Of Poultry Manure

Biological pretreatment of poultry manure has been reported to improve the biochemical methane potential and influence biogas composition during anaerobic digestion. Poultry manure is characterized by high nitrogen content, which can lead to ammonia accumulation and unstable fermentation, reducing methane yield. Biological pretreatment using selected microbial additives can modify the substrate and improve its biodegradability, resulting in enhanced methane production rates and better biogas quality when compared with untreated manure. Studies have shown that maintaining optimal pretreatment conditions and using biological additives can increase methane yields significantly on a volatile solids basis, indicating improved substrate conversion. In addition, biological pretreatment has been found to increase methane concentration in the biogas by up to about 6.3–10.4% and reduce impurities such as hydrogen sulphide, while modifying ammonia dynamics during digestion. Pretreatment also accelerates the uptake of ammonium nitrogen by microbial communities during fermentation, which can contribute to more stable process performance. These results suggest that biological pretreatment of poultry manure is a promising method to optimize the anaerobic digestion process, enhancing methane production and improving overall fermentation performance (Rubežius et al., 2020).

3) CO_2 Injection Into Manure

Injection of carbon dioxide (CO_2) into manure prior to anaerobic digestion has been reported as an effective pretreatment method to improve biogas yield and methane quality. CO2 pretreatment modifies the physicochemical properties of manure by reducing pH and improving substrate solubilization, which enhances hydrolysis and subsequent methanogenic activity. Under mesophilic conditions with an organic loading rate of approximately 1.4 kg VS m^{-3} day^{-1}, CO2. pretreated chicken manure exhibited a substantial increase in biomethane yield from 290.88 L kg^{-1} VS in untreated manure to 374.53 L kg^{-1} VS after pretreatment. In addition, the methane concentration in the produced biogas increased from about 54.7% to 63.1%, indicating improved biogas quality. Similar improvements were observed for cow and pig manure, confirming that CO_2 injection enhances anaerobic digestion efficiency across different manure types. These findings demonstrate that CO_2 injection is a promising pretreatment strategy for optimizing biogas production by improving substrate biodegradability and methane generation efficiency (Žalys et al., 2023).

V. CO – DIGESTION

Mono-digestion of manure often resulted in poor methane production with long retention time due to lack of macro and micronutrients, imbalanced C/N ratio and unfavourable organic rates (R. Li et al., 2017). The ammonium inhibition is also a main problem in anaerobic digestion of chicken manure. Many methods have been investigated, among them the most common method is co-digestion of chicken manure with carbon-rich substrates (Zhu et al., 2024).

Co- digesting with animal manure with different feedstocks increases methane production and is more economic. To achieve an optimum C/N ratio, the co-Anaerobic digestion method is preferred. Co-Anaerobic digestion is a method of treating a mixture of two or more substrates simultaneously, which increases the process overall efficiency by enhancing its stability and sustaining microbial activity (Hakimi et al., 2023).

A. Performance Evaluation of Anaerobic Co-Digestion of Chicken Manure And Chlorella sp.

Anaerobic co-digestion is widely recognized as an effective strategy to enhance biogas and methane production by improving substrate characteristics and process stability. Chicken manure, when digested alone, often leads to lower methane yields due to high nitrogen content, ammonia inhibition, and an unfavorable C/N ratio.

The combined digestion of chicken manure with suitable co-substrates such as microalgae or other organic waste helps overcome these limitations by balancing nutrients, diluting toxic compounds, and enhancing microbial synergy. Co-digesting chicken manure with Chlorella microalgae at an 8:2 ratio showed an increase in methane production by approximately 14.2 % compared to mono-digestion and 76.86 % compared to microalgae mono-digestion, indicating a significant synergistic effect between the substrates (Ruirui Li, Na Duan et al 2017).

When the microalgae were digested alone the process required a prolonged incubation period to produce methane. But co- digestion with incorporating waste activated sludge 59-96 % mass basis increased biogas yield and accelerated the attainment of peak gas production, indicating that co- digestion enhanced the biodegradability of the algal biomass; moreover, co-digestion products showed better dewaterability than digestates from either substrate alone, suggesting synergistic effects in terms of both gas production efficiency and digestate handling (M. Wang et al., 2013).

B. Combined Anaerobic Digestion Of Sawdust And Chicken Manure Using Plant Herbs

Co-digestion of sawdust and chicken manure enriched with plant herbs serai Wangi and peppermint, chosen for their insect-repellent properties to potentially reduce flies attracted by the digestate, and evaluated the effects on biogas generation, methane yield, and kinetic behavior. The addition of sawdust with chicken manure helps to dilute the high nitrogen content of manure and reduce ammonia inhibition, thereby stabilizing the anaerobic digestion process. In this co-digestion system, the incorporation of plant-based additives such as peppermint and serai Wangi has been observed to further influence digestion performance, resulting in enhanced biogas and methane yields at optimized concentrations. Maximum biogas production, approximately 52.28 mL/g VS and methane generation of 30.89 mL/g VS were measured at moderate herb dosages, with an increase in methane concentration about 18.5 % compared to digestion without additives, while higher dosages did not significantly improve performance because of inhibitory substances like lignin and limonene components. So that the combined digestion of sawdust and chicken manure represents a promising strategy for enhancing methane yield and process stability when appropriate substrate ratios and additive concentrations are maintained (Hakimi et al., 2023).

C. Co-Digestion Of Poultry Manure And Corn Straw Under Slurry Recirculation With Air Stripping

Anaerobic co-digestion of chicken manure with carbon rich substrates such as corn straw has been shown to significantly improve fermentation performance, particularly when coupled with mitigation strategies for ammonium inhibition. In systems with biogas slurry reflux, ammonium accumulation can severely limit biogas production and process stability. The effects of air stripping of the digestate to remove excess ammonium prior to recirculation, finding that approach enhanced biogas production and overall digestion efficiency. With air stripping, total ammonium nitrogen levels were reduced by approximately 20 – 40 %compared with digesters without co-digestion, which contributed to improved fermentation conditions **(Zhu et al., 2024).**

VI. PERFORMANCE IMPROVEMENT OF ANAEROBIC DIGESTION THROUGH ADDITIVE SUPPLEMENTATION

A. Carbon Nanotube

In recent years, carbon nanotubes have gained widespread recognition in multiple technological domains in human contributions. Integration of nanoparticles can enhance biogas production. Carbon nano structured material has superior mechanical strength, thermal durability, high electron mobility, selectively binding to inorganic compounds. Recent studies indicate that the integration of conductive materials enhances direct interspecies electron transfer (DIET) within microbial communities, which is vital for syntrophic culture of microorganism in anaerobic system. At the beginning of the experiments, the anaerobically produced biogas performed under for 32 days in mesophilic condition. CNTs are incorporated into anaerobic reactors at various level concentration: $0.5gL^{-1}$,$2.0gL^{-1}$,$5.0gL^{-1}$. The aim of this study is to evaluate carbon nanotubes on the production CH4 from the chicken manure. The methane yield increased in the including CNTs in the concentration of $5.0gL^{-1}$ throughout the experiment. In the second batch of the experiment carried out by 5 conditions they are MFR, SMP, acetate, propionate and butyrate with CNTs presence results in lower level of Total ammonia nitrogen and reduces inhibition by ammonia and anaerobic system higher concentration of volatile fatty acids produced as a result of abundant organic matter. In all experiments where carbon nanotubes were incorporated, the volatile organic acid level consistently decreased throughout the anaerobic digestion process. In contrast, the experiments conducted without CNTs addition exhibited a lower rate of VAO utilization. In the second batch of the experiment carried out by 5 conditions they are MFR, SMP, acetate, propionate and butyrate with CNTs presence results in lower level of Total ammonia nitrogen and reduces inhibition by ammonia and anaerobic system (Ziganshina et al., 2022).

B. Gac, Biochar, Magnetite

The biochar is sourced from bamboo, rice, rice husk, sewage sludge and wood, additionally sheep manure and wheat straw generate adverse effects. These are porous structured material which is similar to charcoal like material by using pyrolysis methods. It is used as a solid enhancer. Adding biochar to organic input in dry anaerobic digesters improves biogas formation and methane output. This system helps to reduce the hydrogen sulphide and prevent corrosion and extend system lifespan (Collins et al., 2025). In the preliminary phase of experiments, the conversion rates of methane production and flow rates induced by varying concentrations of magnetite, GAC, and biochar are utilised to assess the optimal concentration within the anaerobic system. The properties of GAC and biochar promote surface associated microbial community formation; it improves the tolerances of microorganisms toward diverse toxic compounds can eventually enhance their overall microbial activity. Magnetite combined with biochar, GAC triggers in

anaerobic reactors influence the microbial and archaeal consortium while the reaction occurs. In present study, five experimental parameters were tightly regulated control reactors(C1), reactors supplemented with Fe_3O_4 (M1); reactors augmented with granular activated carbon (G1); reactors augmented with both GAC and magnetite (GM1); and reactors augmented with biochar (B1) these are operated within 25 days to analyzes state of factor. Methane production rate is increased due to addition of GAC, magnetite, biochar. On day 11 the specific methane production from C1, M1, G1, GM1 and B1 achieved 116 mLg^{-1}. 114 mLg^{-1}, 131 mLg^{-1} and 119 mLg^{-1}. Methane production peaks faster in day 11-12 due to the incorporation of additives. In GM1 reactors 20% of the methane production substantially increased in contrast to C1 reactors, most of the methane generated on the day 12 in C1 reactors generated in day 15. Additionally parameter such as pH, VOA and TAN analyzed. The lowest pH found in day 3 throughout the process to stabilize the condition at the pH of 7.5. When the C1 pH drops increases and reduces the process. During the digestion period the infusion of the additives which reduces VOA concentration which means it produces the acid formation for decrease CH_4.The mean acid capability maintained in the digester in the range of 2.4 -2.6 gL^{-1}, C1 has lower in the beginning of the treatments. With the help of the additives digestion efficiently carried out by the organic acid transformed into biomethane. The study established that with the aid of the chicken manure and inclusion of the additives in digesters to acquire CH_4 production rate and the product stability is high, the combination of the additives rapidly improves CH_4, perform much better than control reactors (Ziganshina & Ziganshin, 2022). To provoke the methanogenesis, magnetite is added it improves biomethane production drastically increased by 16%. The combination of the magnetite and GAC supplements enhances the production up to 80% due to the process of direct interspecies electron transfer, the electron exchanges between bacterial community species and methanogenesis which involves directly in electron exchanges. By the addition of the both supplements increase the methanosaeta species 10-18%. The magenite is a solid crystalline structure form of ferric and ferrous oxides with free mobility enables to enhances DIET for electron exchanges between the syntrophic and methanogens archeal. Methanogens genus of the methanobacterium are capable of hydrogen utilizing bacterium for maintain hydrogen pressure balance in digester. Despite accounting of the microbial Communities relatively abundance is limited to approximately 10%. Magnetite helps to break complex substrate into simpler compounds, it generates the hydrogen utilized by the methanogens compounds CH_4 production. The presence of bacteria *Ruminococcaceae* and *clostridiacecae* are 30% in supplements digesters, which regulates complex waste degradation. The results indicates that the supplements enchances the productivity to facilitates the electron exchanges between the bacteria and the methanogens, substantially improves the decomposition of complex into simpler components and efficient conversion of volatile Compounds (Tawfik et al., 2023b).

VII. PURIFICATION

In the chicken manure contains more nitrogen due to this at the time of digestion high level of TAN generated, to deal with this dilution water improves secondary wastewater which increases water consumption. Large volume of digester improves a biogas production at a stable TAN concentration is maintained. The ammonia concentration maintained under the conditions like high dry matter and high organic loads to enhance stable biogas production. Several physiochemical methods are available for ammonia removal; leach bed, struvite precipitation and ion exchange. It cannot be operated on the continuous operation in digesters. To mitigate the ammonia inhibition and stable condition can be maintained by digester frequently applied a significant amount of water infused at the time of digestion called wet anaerobic digestion.

C. Leach Bed Reactor For Dry Anaerobic Digestion Of Solid Waste

Leach bed reactor (LBR) is an encouraging for agricultural waste, municipal waste, food and kitchen waste, potential path for dry anaerobic digestion of high solid containing waste. The advantage of LBR is simple method, cost effective one, highly efficient in digestion of solid waste and requirement of water is low. Although having disadvantages. To eliminate clogging and channeling problems by applying bulk agents such as sawdust, straw and agricultural waste. Increase rate of permeability in leachate produces uneven distribution of leachate is affected by the heterogeneous structure of waste and VFA accumulation (Bayrakdar et al., 2018).

D. Struvite Precipitation

It is the method to retrieve the ammonia in the form of solid. The majority of ammonia salt is rapidly soluble water and fails to precipitate. The combination of magnesia, ammonia and phosphate are commonly known as struvite. Struvite precipitation is a subsequent treatment step for phosphate recovery. It varies depending on requirements for ammonia, phosphate or both. Infusion of magnesia and phosphate in digesting can improve the ammonia inhibition lead to 25-40% increase in methane production. The operational constraints are the increase amount of suspended solids disturbs the precipitation because of solid settling, technical process complicated and increased cost (Fuchs et al., 2018).

E. Ion Exchange

These materials can be used as a support matrix to immobilize and retain biomass within the bioreactor. The commonly used materials are zeolite, clay, manganese, and bentonite. By the usage of these materials can enhance the organic load and decrease hydraulic retention time, it results the process of anaerobic digestion can be carried out efficiently. Furthermore, to increase ion exchange capacity include micronutrients like Ni, Co, Mg. It works as alternate key for methanogenic bacteria. Excessive addition of zeolite leads to heavy metal accumulation. Biomethane production increased by 79.4% when ash was added to the AD process of waste activated sludge (Aworanti et al., 2023).

VIII. ANALYTICAL METHODS

In the digestate the amount of VFA levels determined by gas chromatography with static headspace injection methods. To estimating the level of the ammonia, magnesium, potassium and calcium by ion chromatography with Pa CS12A separation column. The quantity of the total protein can analyze by Lowry- Folin method using BSA. Evaluating the total Polysaccrides by the method of Anthrone-sulfuric acid with standard glucose. To assess the impact of ammonia removal on methanogenic communities by using Quantitative PCR (qPCR)(Tao et al., 2017). The VFA were identified by High-Performance Liquid Chromatography and the gas formation rate existed and monitored by vacuum glass syringe. The composition of biogas studied by GC136 gas chromatography with TDX Column and TDC detector (Chen et al., 2025). The rate of pH can be estimated by digital pH meter. The TAN ascertained with the help of salicylic acid-hypochlorite spectrophotometry. The volume of CH_4 and CO_2 confirmed by UV-VIS spectrophotometer. The potassium permanganate oxidation method was used to measure the soluble chemical oxygen demands (Duan et al., 2018). The total phosphorous can be calibrated by ammonium molybdate spectrophotometric method. The humic acid analyzed by potassium dichromate oxidation method (Liu et al., 2025).

IX. VALORIZATION OF BIOGAS

Biogas produced through anaerobic digestion (AD) primarily comprises methane (CH_4) and carbon dioxide (CO_2), in addition to trace quantities of other gases. Anaerobic digestion, whether conducted independently or within a co-digestion framework, can yield sustainable sources of clean energy. The methane content of biogas typically varies from 50% to 75%, contingent upon the specific feedstock utilised. This methane can serve as an alternative to natural gas, whereas leftover decomposed material can be utilized as a nutrient-enriched fertilizer containing nitrogen, phosphorus and potassium (Ayantokun et al., 2025). Waste-to-energy (WtE) technologies for the treatment of poultry manure (PM) include both thermochemical and biological conversion pathways. Thermal degradation process consists of combustion pyrolysis, and gasification, while biological conversion primarily involves anaerobic digestion (AD). In AD, poultry manure is broken down under anaerobic (oxygen-free) conditions through biochemical processes, producing biogas and a nutrient-rich digestate. The biogas produced can be converted into biomethane, a renewable fuel that can be used to generate electricity and heat. In gasification, the biomass is partially oxidized at high temperatures (500–1800 °C) using oxygen, carbon dioxide, steam, or a combination for the reaction phase. Pyrolysis, on the other hand, performed in oxygen-free at relatively low temperatures (250–900 °C), resulting in the production of bio-oil, syngas, and char (Boakye-Yiadom et al., 2024).

X. CONCLUSION

Chicken manure has high potential to induce a metabolic pathway, pre-treatment modifies the physicochemical properties of manure by reducing pH and improving substrate solubilization, microorganism's breakdown into biodegradable organic matter under the absence of oxygen. The inclusion of corn straw, sawdust, carbon nanotubes, microalgae, additives and plant herbs is used to enhance the biogas production efficiently. The additives drastically increase biogas production by 16%. GAC triggers in anaerobic reactors influence the bacterial and archaeal communities during the anaerobic digestion of poultry manure. Chicken manure with carbon-rich biomass feedstock including corn straw has been shown to significantly improve fermentation performance. The effects of air stripping of the digestate to remove excess ammonium prior to recirculation, finding that approach enhanced biogas production and overall digestion efficiency. Infusion of magnesia and phosphate in digester can improve the ammonia inhibition leads to 25-40% increase in methane production. Increase ion exchange capacity include micronutrients like Ni, Co, Mg. It works as alternate key for methanogenic bacteria.

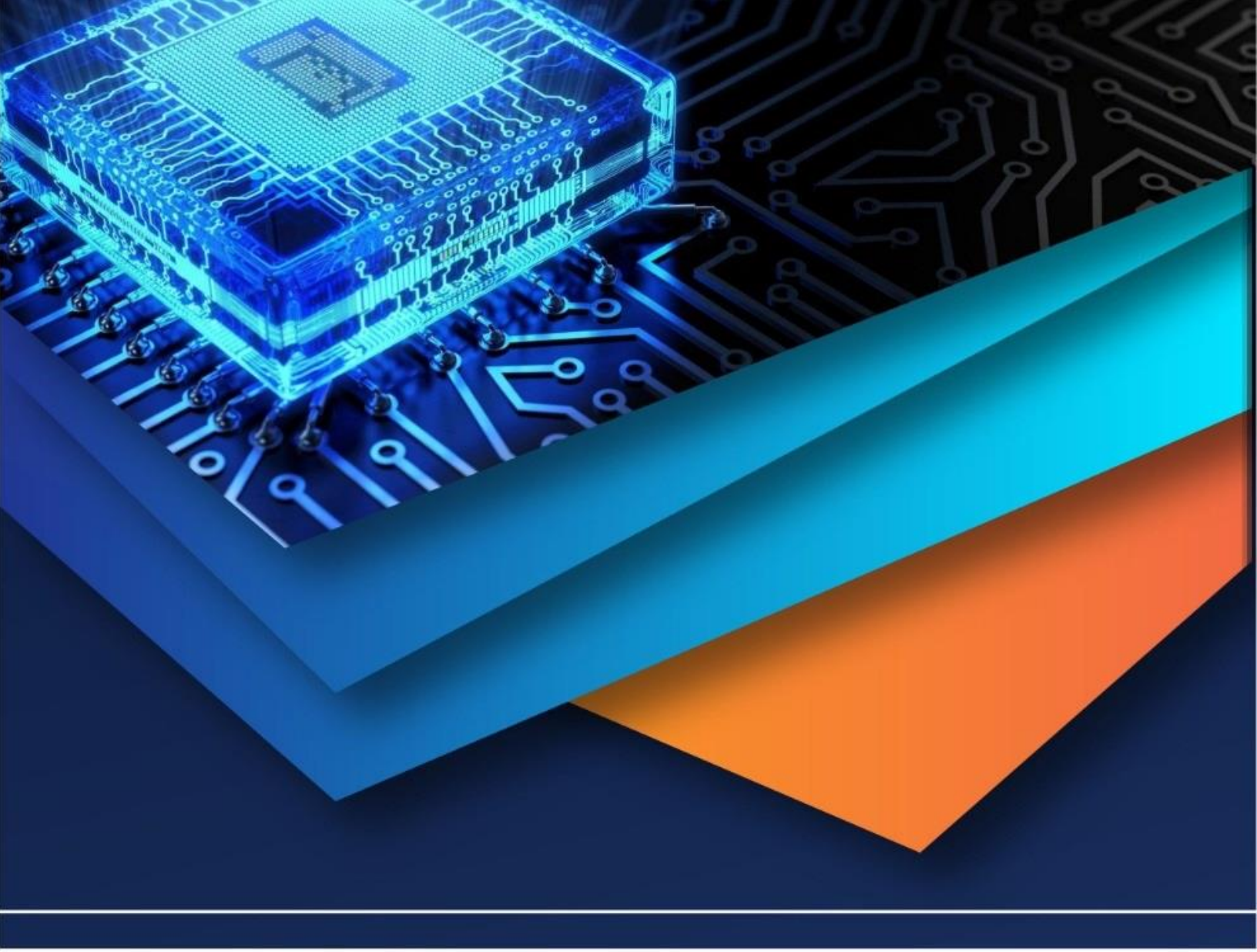
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