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Chemical Characteristics of Chicken Litter Waste in Closed-House System

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Abstract—**Waste from the broiler and layer farming industry with a closed-house system continues to increase without optimizing waste utilization and harms the environment. Potential chicken litter waste from the chicken farming industry in West Sumatra is 5 tons per harvest (40 days) from a chicken livestock capacity of 100,000 chickens. This research aims to assess the potential and utilization and study the biochemistry of chicken manure waste in closed-house systems as biosorbents and fertilizers through amelioration technology. Closed-house chicken coop bedding waste (CHCCW) in the form of sawdust has functional groups such as carboxyl that can absorb cations because it can increase the negative charge in the soil so that it can be utilized by plants. In addition, the CHCCW can also absorb cations (pollutants). Chemical characteristics from the analysis results prove the ability of the CHCCW. Chicken litter waste has chemical characteristics that have the potential as a biosorbent and are valid as fertilizer, which has a proximate composition (moisture 4.26%; volatile matter 74.20%; ash 6.78% and fixed carbon 14.76%); pH (pH H_2O 8.37 and pH PZC 7.37); electrical conductivity (EC) >2 dS m^{-1} and cation exchange capacity (CEC) 182.67 Cmol(+)kg^{-1}. The nutrient composition of chicken manure waste in closed-house systems has macro nutrients (6.88% C; 0.06% N; 5.89% P; 34.89% K; 36.28% Ca; 5.76% S) and micronutrients (2.49% Fe; 1.39% Mn; 1.22% Zn; 1.01% Cu; and 5.15% Cl). Chicken manure waste in closed-house systems also has functional groups such as O-H, N-H, C-H, C-OH, C=C, C=O, C-O-C, Si-O, and O-CH3, which play an active role in the absorption of pollutants and nutrients in the soil.**

Keywords— **Ameliorant; biosorbent; chicken litter waste; closed house system; organic fertilizer.**

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I. Introduction

Increased animal protein consumption led to intensive livestock breeding and a notable rise in manure production worldwide [1]. Worldwide livestock operations are expanding at an unprecedented rate, increasing manure production. Furthermore, animal excrement has the potential to be used as a renewable energy feedstock to generate electricity [2]. In addition, it also leaves residues in the form of waste that needs to be recycled. Chicken farm waste continues to be of particular concern as a cause of environmental pollution. According to [3], materials from waste like manure and chicken litter can be hazardous to the environment and public health. Thus, they must be handled carefully. The production of poultry and its byproducts are associated with emissions of NH_3, N_2O, and CH_4, which affects greenhouse gas emissions worldwide and has an effect on the health of humans and animals.

The waste generated comes from the size of the chicken farming industry, especially chicken coops with a closed-house system. The capacity of closed-house cages is 2-3 times larger than open-house cages. Closed broiler chicken coops with a population of 22,000 strains per harvest season for broiler chickens [4]. Microorganisms that are both saprophytic and potentially pathogenic can be released into the outdoor air by intensive chicken farms [5].

When using a closed-house method, chickens are occasionally housed in closed cages that provide biological safety (interaction with other species) and have adequate ventilation systems to reduce animal stress. With a closed-house arrangement, chicken waste is created by mixing chicken excrement with the coop bedding to mask the smell of the birds' droppings and keep the coop at a constant temperature. Thus, a chicken coop with a closed-house system requires more odor-absorbing materials, such as waste sawdust or rice husks, as a cage base.

Chicken litter is described as a mixture of chicken feedings, bedding materials, and waste [6]. However, the utilization of each waste harvest is not optimized correctly. This waste is a source of environmental pollution in the form of gas emissions and the leaching of nitrates and other pollutants into groundwater. The production of poultry hurts the environment since it releases NH_3, a greenhouse gas, and nitrous oxide, along with contaminating surface and groundwater [7].

Sometimes, chicken litter, a mixture of chicken manure and coop bedding, is an exciting waste formulation to study. The conversion of chicken waste into beneficial by-products appears to be a viable strategy for improving sustainability by producing valuable items from the disposal of poultry waste [8], one of which makes the manure into fertilizer. The composition of the cage bedding varies depending on the owner of the chicken farming industry. The identification results in West Sumatra showed that the cage base used in the closed-house chicken farming industry was sawdust and rice husk; in this case, sawdust was the most widely applied.

Poultry manure contains elements that have the potential for plant needs. Improving the quality of chicken production is followed by improving the quality of feed that includes optimal nutrition so that the remnants of supplements or manure are collected on the cage bedding. Chicken manure is a nutrient-rich organic waste frequently used untreated as an organic fertilizer in agricultural areas. It includes significant amounts of nitrogen, phosphorous, and potassium [9].

Rich sources of nutrients like nitrogen, phosphorous, potassium, and other macro- and micronutrients for crops can be found in poultry litter and manure waste, which can also assist in raising the amount of nutrients available in the soil. Additionally, adding poultry manure to the soil as a soil amendment releases nutrients and organic materials [10]. Rice husks and sawdust are frequently utilized as litter materials, particularly for raising broilers and chicks. Furthermore, wood waste, such as sawdust, is a vast potential supply. A large amount of wood waste, such as sawdust, is produced by sawmills [11]

Thus, the formulation of chicken coop waste using a closed-house system formed from industrial processes needs to be developed through amelioration technology, which functions as a biosorbent and organic fertilizer. Waste can be used as a potential raw material to support human life through several potential analysis processes of its characteristics, especially closed-house farm waste in the West Sumatera Regency. An essential element of the circular economy is converting organic waste into farmland. [12]. Chicken litter in fertilization because it is low cost and has good agronomic characteristics [13].

Most lignocellulosic materials like wheat and rice straw have more carbon and hence a larger C/N ratio than animal waste and sewage sludge, which are rich in nitrogen from urine and have lower C/N ratios [14]Sawdust is another substance commonly used with chicken manure. Compared to pre-crops, sawdust application stabilized bacterial diversity and increased soil carbon (C) stores. [15].

Sawdust is standard and readily available from woodworking companies in Indonesia. The woodworking industry produces wood waste in 22% wood scraps, 8% wood chips, and 10% sawdust [16]. Thus, sawdust waste abundant from woodworking companies can be utilized further. Closed-house farm waste needs to be studied more regarding its potential in terms of physical and chemical characteristics to solve environmental waste problems.

Sawdust also has a composition of nutrients needed for plant growth and development. The N content in these wood fibers is a supplier of N and can be used as a fertilizer material. In addition, sawdust has pores that help absorb other nutrients so they do not leach into the groundwater. The pore is also assumed to absorb contaminants to resolve environmental problems. Brunauer-Emmett-Teller (BET) surface area from wood sawdust showed 1.384 m^2/g [17]. Thus, the use of sawdust as coop bedding has the potential to be used for agricultural integrity. The presence of sawdust in chicken litter material can also be a water trapper that carries dissolved elements in the soil.

The primary ingredients of sawdust are cellulose and lignin, found in the acid-detergent fiber that makes up a portion of the material. Sawdust also includes various hydroxyl groups, including tannins. These elements are significant primarily because of their capacity to draw cations through an ion exchange mechanism [18].

The objective of this work was to investigate the variations of the psycho-chemical properties (moisture, pH, electrical conductivity (EC), organic matter (OM), and N-total of chicken litter mixed with sawdust. In this study, chicken litter must be prepared before being analyzed through the drying process at room temperature or heating with a specific temperature and time to get safer samples to apply to the soil and minimize the spread of pests and diseases from chicken litter pathogens on plants.

II. Material and Method

A. Materials

Fig. 1 shows chicken litter waste with a closed-house system obtained from several livestock industry wastes in West Sumatra as the raw materials used in this study.

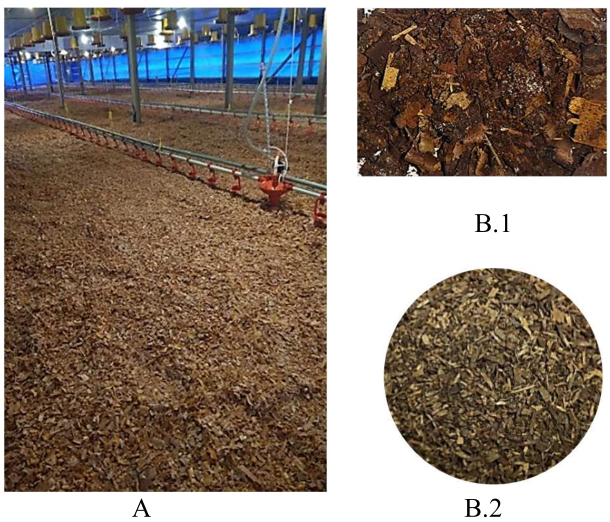

Fig. 1 Visualization of Chicken Litter in Closed House System (A) and waste from chicken litter in closed house system (B.1) with sieve pass ≤ 2 mm at 70 ^{0}C (B.2).

The equipment used is an oven (Memmert UN30), analytical balance (Kern ADB 200-4), 10 mesh sieve (AMB No. 10), furnace (SH Scientific Laboratory Muffle Furnace SH-FU-27MG), desiccator, spatula, 500 mL beaker glass, 10 measuring cups, 50 and 100 mL, porcelain glass and Erlemeyer 50 and 100 mL. Scanning electron microscope/energy dispersive X-ray spectroscopy (SEM/EDX, CARL ZEISS type EVO MA 10), X-ray fluorescence (XRF, Philips PAN analytical Minipal 4), and Fourier Transform Infra-Red Spectrophotometer (FT-IR, Prestige IR 21).

B. Procedure

Chicken litter has been taken when it has become a post-harvest waste of chickens in the poultry industry. The waste is allowed to air dry until the pungent odor has begun to disappear and the water content of the material is reduced. For the next step, Chicken litter was prepared in the laboratory by drying it in an oven at 70 ^{0}C for 2x24 hours and sifting using a 10 mesh or 2 mm sieve [19] (Fig. B.2). The heating and drying process is carried out to reduce the development of pathogens in chicken litter material so that it is safe if used as an ameliorant for the soil. The high water content of the material becomes a breeding ground for pathogens. The temperature and time are adjusted so that the natural composition of the chicken litter does not change and can be used as a benchmark for the analysis results later.

Samples were analyzed to study the chemical characteristics of chicken litter waste. The chemical characteristics analyzed were proximate composition (moisture, volatile matter, ash, and fixed carbon) [20] pH, electrical conductivity (EC) with a pH meter, cation exchange capacity (CEC) by leaching NH_4OAc pH 7, and nutrient composition (Walkey and black method; Kjeldahl method [21] and XRF analysis) [22]. Scanning electron microscope/energy dispersive X-ray spectroscopy (SEM/EDX) is employed for examining the microstructures [23], and Fourier Transform Infra-Red Spectrophotometer (FT-IR) was obtained to check the presence of different functional groups [24].

III. Results and Discussion

A. FTIR

FTIR, or Fourier transform infrared spectroscopy, is commonly used to distinguish between the hydrocarbon functional groups in chicken litter. The distribution of hydrocarbon functional groups and the variations in the composition of the chicken litter samples under study were ascertained using FTIR. The FTIR technique is commonly used to characterize and assess the location and area of distinct wave peaks on the surface of carbon materials to determine the type and amount of oxygen-containing functional groups. This method has the advantages of having solid characteristics, quick determination, and non-destructive samples [25].

The results of FT-IR measurements in the form of a spectrum are shown in Table 1 and Fig 2. The peaks appear to identify several functional groups. The wave number is 4000 - 400 cm, with a 68 - 82% transmittance range. The wave number in chicken litter waste was identified as 3277.95/ 78.89% - 3741.81/76.73%, which explains the presence of O–H and N–H stretch groups. The wave number at 2925.64/ 77.58% explains the presence of C–H stretch and C–H stretch of CH3, while the wave numbers 2019.77/ 78.34% - 2167.33/78.34% indicate the presence of Isothiocyanate (-NCS) and Thiocyanate (-SCN). Tables 1 and 2 show this experiment's FT-IR spectrum of chicken litter.

TABLE I
Characteristics of Spectral Band Assignments of Chicken Litter Waste in Closed House System

CM-CHS Wavenumber/ Transmitan (cm^{-1}/ %)	Band Assignment
3741.81/ 78.89 3277.93/ 76.73	O–H and N–H stretch
2925.64/ 77.58	C–H stretc; C–H stretch of CH_3
2167.33/ 78.34	Thiocyanate(-SCN)
2019.77/ 78.34	Isothiocyanate (-NCS)
1634.04/ 75.69	Aromatic C=C, Hydrogen bond C=O, double bond conjugated with carbonyl and COO vibrations
1423.71/ 76.25	C–H bending
1101.06/ 73.45	C–C, C–OH, C–O–C typical of glycosidic linkages, Si–O impurities, C–O stretch of polysaccharides
1029.26/ 73.25	O–CH_3 vibrations
530.48/ 70.98 447.47/ 78.16	Aromatic C–H vibrations and Mineral

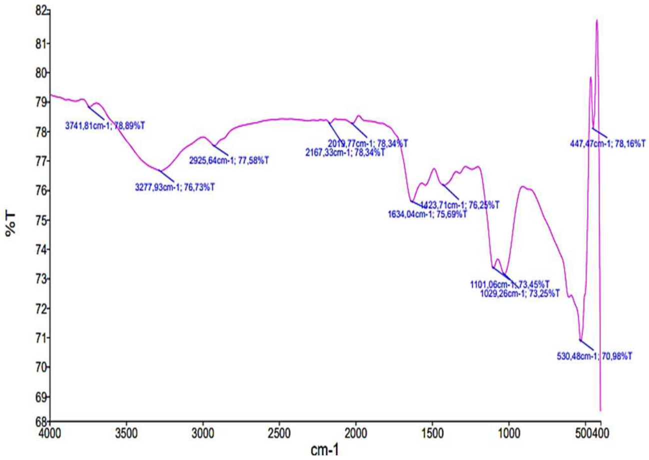

Fig. 2 FT-IR spectrum on chicken litter waste in closed house system

Wave numbers are also identified from 1029 - 1634 which explains the presence of O–CH3 vibrations, C–C, C–OH, C–O–C typical of glucoside linkages, Si–O impurities, C–O stretch of polysaccharides, C–H bending, aromatic C=C, Hydrogen bond C=O, double bond conjugated with carbonyl and COO vibrations and aromatic C–H vibrations and Mineral at wave number 530.48/70.98%. All identified peaks are active groups (phenol and carboxyl groups) [26].

A significant band in the range 1674-1625 cm-1 is related to the stretching vibration of C=O bonds in COO groups [27]. The exchange sorption of carboxyl groups present on the solid phase surface of manure is their most important. The findings of FT-IR measurements support a considerable contribution to this process. In the case of manure, the carboxyl groups were expected to be primarily substituted with ions (K^+, Na^+, Mg^{2+}, Ca^{2+}) [28].

Conversely, Through the denitrification process, these function groups can also lessen the amount of N lost in the soil. whereas carboxyl, carbonyl, and quinone functional groups can compete with microorganisms for electrons and thereby inhibit the reduction of N_2O to N_2, oxygen-containing functional groups, such as phenolic hydroxyl functional groups, can provide electrons to promote N_2O reduction and subsequently reduce soil N_2O emissions [29].

Manure contains carboxyl groups with a reactive surface and a negative charge when absorbing cations or contaminants. Based on the results of FT-IR, it is known that there is a carboxyl group that is considered to help increase adsorption by litter fertilizer. Based on [30] research suggests that carboxyl groups are involved in metal ion sorption. The dissociation of hydroxyl groups in carboxyl will determine the negative charge that affects a material's absorption ability to contaminants. The negative charge will bind the positive charge to the contaminant, allowing adsorption.

Isothiocyanate (-NCS) and Thiocyanate(-SCN) are nitrogen multiple and cumulated double bond compound [31]. Plants need nitrogen to grow and develop. Therefore, chicken litter can be used as a source of nitrogen. The application of chicken litter in vegetable production, such as in the growing of red peppers, may improve the nutrient content of the soil and encourage plant growth [10].

Chicken litter was used to improve nutritional availability and absorption. Lowland rice production frequently uses nitrogen fertilizers, P, K, S, Zn, Fe, Mn, and B; yet N, P, and K fertilizers comprise approximately 92% of the essential nutrients used in rice agriculture. The compound's bond demonstrates the presence of nitrogen in the closed-house chicken litter [32]. The compound's bond serves as a visual representation of the nitrogen content of the indoor chicken litter.

Sawdust present in chicken litter can help remove contaminants. Removing heavy metal ions, dyes, poisonous salts, etc., attracted much attention to this attractive material in the past. The most likely main mechanisms were hydrogen bonding and ion exchange because the sawdust structure has several groups containing -N, -O, -S, and -P. The primary mechanism is ion exchange when metal ions with positive charges adhere to sorbent surfaces with negative charges. Heavy metal ions can take on a variety of shapes in a solution with a specific pH, such as M^{2+}, MOH^+, $M(OH)_2$, etc., for a divalent metal ion. Therefore, the following equations can be used to determine the likely mechanisms [33].

Further treatment of chicken litter samples such as biochar and ash has more potential to be used as heavy metal trappers. By the results of the study [34] revealed that the physicochemical characterization of the stabilized samples highlighted that poultry litter ash behaves adequately in terms of heavy metal stabilization.

B. SEM/EDS Analysis

SEM/EDX analysis is used to understand the morphology or surface of the material, and EDX analyzes the material components or atomic composition of chicken coop waste. Fig. 3 displays the SEM analysis findings.

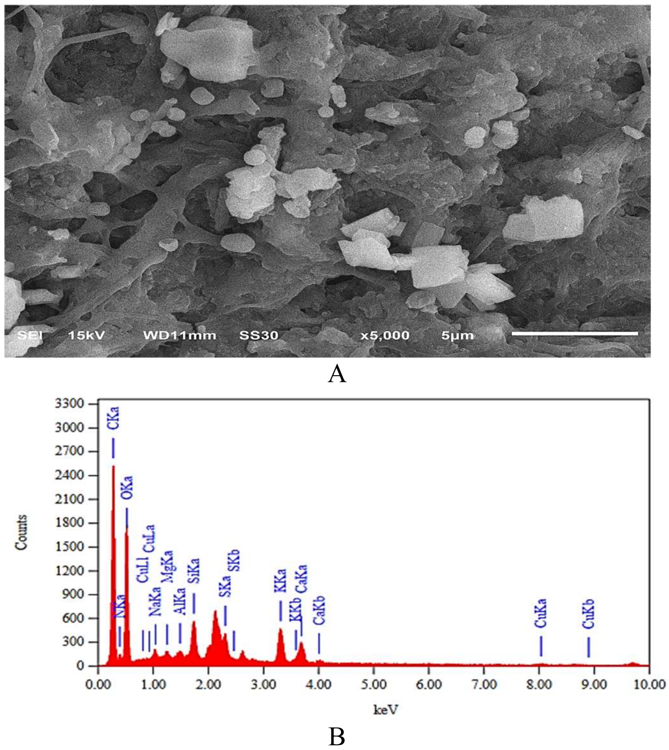

Fig. 3 SEM (A) and EXD (B) on chicken litter waste in closed house system

SEM results of chicken waste sometimes show the presence of molecules and organic material from the pore channels, and the presence of pores and uneven surfaces (Fig. 3A). The pores seen in the scan using an electron microscope become a place for contaminants to be deposited and bind to the loads in the chicken litter. In addition, the pores will be filled with water that carries the elements needed by the plant so that it does not leach into the water below the surface.

Furthermore, the EDX results show all the elements contained in the material by converting them into percent (%). The results of the EDX examination of chicken manure are presented in Fig. 3B, which shows the atomic components examined quantitatively. The identification results showed the presence of elements C, N, O, Na, Mg, Al, Si, S, K, Ca, and Cu. The highest atomic composition component is 42.15% C, 35.07% O, and 18.59% N. The other composition is only 1.19% K, 0.88% Si, 0.80% Ca, 0.42% S, 0.29% Na, 0.25% Cu, 0.19% Mg, 0.17% Al. However, these elements can be additional support to increase soil fertility.

The mixture of sawdust in chicken litter causes the sample to absorb contaminants when applied to the soil. [35] The content of lignin, tannin, and other complex compounds in sawdust can supply nutrients and absorb solutions, so in some developing countries, it is used as mulch on agricultural land. In addition to a range of extractives, the three primary constituents of sawdust, often known as wood waste, and are cellulose (45–50%), lignin (23–30%), and hemicellulose (20–30%). Since sawdust is a common natural adsorbent and one of the least expensive remediation techniques, it is typically used to remove pollutants from soil or water [36]

This is also evidenced by the surface area of sawdust so that there is a chance for contaminants to be trapped. The surface area of sawdust was (0.969 m^2/g), around 1.39 times that of raw sawdust. The performance of this adsorbent in removing impurities (Si, Al, Fe, and Cu) was superior [37].

Different sawdust-based adsorbents had adsorption capacities ranging from 10 to 667.9 mg/g (for endocrine-disrupting chemicals and other emerging contaminants removal), 69.44-372 mg/g (for pesticides, herbicides, and agrochemicals removal), 3.42-526.3 mg/g (for dyes removal), and 2.87-325 mg/g (for heavy metal removal) [38].

C. Chemical Characteristics of Chicken Litter Waste in Closed House System

Based on the results of FT-IR, SEM/ EDX confirmed that chicken litter waste sometimes accumulates organic compounds. The results of the proximate composition showed that the moisture was 4.26% after being standardized using an oven at 70 ^{0}C for 2 x 24 hours. The ash composition is 6.78%, a mineral component in chicken coop waste such as Si, shown in the FT-IR and SEM/ EXD results. the volatile matter composition is very high at 74.20% with 14.76% fixed carbon (Table 1).

Proximate analysis in chicken litter illustrates the material's potential for ash and carbon and moisture levels. The poultry litter ash's elemental composition revealed that the proportion of alkali metals was higher [39]. The alkaline content of the material will undoubtedly affect the pH of the chicken litter material.

The pH of chicken litter as fertilizer is essential in influencing the composition and quality of fertilizer. This is because poultry manure may also increase soil pH, and nutrient (N, P, K, Ca, and Mg) content. pH will determine the chemical characteristics contained in the ameliorant material. Carbon materials' surface acidity and alkalinity are defined by the point of zero charge (pH PZC). It refers to the pH value in aqueous solution when the net charge of the solid surface is zero, and it is commonly employed in potentiometric and mass titration [40].

TABLE II
DESCRIPTIVE STATISTICS OF CHEMICAL CHARACTERISTICS OF CHICKEN LITTER WASTE IN CLOSED HOUSE SYSTEM

Analysis		Unit	Mean	SE	SD
Proximate	Moisture	%	4.26	0.03	0.06
	Volatile Matter		74.20	0.28	0.49
	Ash		6.78	0.39	0.69
	Fixed Carbon		14.76	0.26	0.45
pH H_2O		Unit	8.37	0.09	0.15
pH KCl			7.87	0.12	0.21
pH PZC			7.37	0.17	0.29
*ΔpH			-0.50	0.06	0.10
EC		dS m^{-1}	> 2.00	0.00	0.00
CEC		cmol(+) kg^{-1}	182.67	22.05	38.19
C Organic		%	6.88	0.50	0.87
Total N			0.06	0.01	0.03
C/N Ratio		Unit	156.12	62.3	107.82

Remarks: PZC = Point of zero charge; EC = electrical conductivity; CEC = Cation exchange capacity; SE = standard error; SD = Standard deviation; n = N = Number of observation values (3); * = pH KCl – pH H_2O.

Chicken litter waste has a pH H_2O of 8.37 and a pH of PZC of 7.37. This shows that the pH of PZC is below the pH value of H2O, which confirms that chicken waste is dominated by negative charges. The negative charge can be measured by subtracting the pH of KCl and the pH H2O, where the negative charge of chicken litter waste is 0.50. This is confirmed by the high CEC from chicken coop waste, which is 182.67 cmol(+) kg^{-1}.

The point of zero charge (PZC) is typically used to characterize adsorbents, particularly in ion adsorption studies from aqueous solution. In summary, the ability of the soil to absorb and exchange cations (CEC) can be known based on the pH of the PZC contained in the organic material to be added to the soil. Overall, the pH of PZC is also directly related to acidity factors in chicken litter, such as the influence of pH H_2O. PZC refers to the existence of equal positive and negative charges. This indicator is critical for determining good soil quality and avoiding contamination and pollution [41].

Chicken litter has a pH of 8.37 and can improve soil pH if ameliorated. Thus, the content and fertilizer value of poultry litter are also influenced by the pH of the litter. on non-acidic soils, poultry litter can have an optimal effect on nutrient availability. Poultry litter is a significant supply of phosphorus-containing a high phosphorus-to-nitrogen ratio, although its availability is limited at deficient pH levels [42]. Based on [43], experiments showed a pH of 7.8 and organic matter of 85%. On the other hand, [44] reported that poultry litter contains pH 7.8, N 0.5%, EC 4.09 dS/m, and organic carbon 23%.

The potential for this charge is also supported by the electrical conductivity of >2 dS m^{-1} of chicken coop waste. Nitrogen is the limiting reagent of the chicken litter mixture when applied to cropland; thus, plant farmers spread the chicken litter in adequate quantities to meet the crops' N requirements. Chicken litter can stimulate microbial presence to decompose sawdust, a component of chicken litter with a C/N ratio of 156.12 units. The C/N ratio is related to the growth and activity of the microbial population.

Organic matter from chicken manure in another experiment showed 69.74% [45] that contains C Organic. Poultry litter contains both organic and inorganic nutrients. Inorganic forms of N, such as nitrate and ammonium, are instantaneously available for plant uptake and utilization regardless of source, but organic forms of nutrients are less immediately available for plant adsorption [46]. For many years, poultry manure has been utilized as an inexpensive organic fertilizer, which has improved crop development and output while also encouraging the return of natural soil processes [47].

Microbes can use the presence of C in raw materials to grow and flourish, increasing nutrient availability. They consume C-containing chemicals to generate carbon dioxide and N-containing ones to generate ammonia. As a result, the high C content of litter promotes microbial activity and increases ammonia and carbon dioxide emissions. [48].

Chicken feces, bedding material (such as pine shavings, sawdust, and peanut hulls), feathers, and waste feed are the main components of chicken litter. It can give ammonium and nitrate, the solid forms of nitrogen that plants can use immediately. The early forms of N in the feces (uric acid and proteins) begin a chemical transformation process based on the start of deposition.

The total N of chicken litter can improve soil fertility with a high total N compared to other materials. Suppose uric acid is appropriately integrated into the soil. In that case, it can be transformed into ammonium, which can be held on clay particles and organic materials, minimizing losses and improving plant availability through the adsorption of -N. Other experiment, [43] reported that compared to rice husk (0.38%), the nitrogen concentration of chicken litter (5.38%) was much higher. This was owing to the high protein content of the chicken litter. Fig. 4 depicts the nutritional component of chicken litter in this experiment.

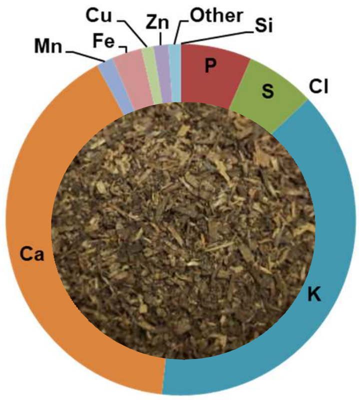

Fig. 4 Nutrient composition on chicken litter waste in closed house system by XRF analysis.

Fig. 4 shows the percentage of essential and non-essential compositions in chicken litter in which K+ and Ca2+ are dominant percentages, followed by S>P>Fe>Mn>Zn>Cu and others. Analysis of the mineral composition of the chicken litter may show considerable nutrient contents that plants need [49]K and Ca are macronutrients for plants, so chicken litter has the potential to be used as a source of nutrients in the form of fertilizer. When used as fertilizer, chicken litter contributes some nutrients and can provide many micronutrients for plants.

Thus, chicken litter is a fertilizer that provides enough macro and micronutrients. Furthermore, using ameliorants that can be used as fertilizers, such as chicken litter, does not leave residues of factory activities in the soil, so it is more environmentally friendly and can support sustainable agriculture. K is necessary for all living cells to operate and is a crucial component of plant nutrition. A rich source of K for plant growth is dairy manure. Livestock waste is the best fertilizer for nutrient-deficient soils because it contains both macro and micro components, which together improve crop quality and output [2].

The essential and non-essential nutrients used for plant growth are nutrients and fertilizers. Chicken litter was abundant in K, Na, and Mg [31]. All of the findings in the experiment about chicken litter mixed with rice husk is supported by [50]. This waste is highly prized as fertilizer by the region's agricultural and livestock producers and other area economies.

The essential and non-essential nutrients used for plant growth are nutrients and fertilizers. However, chicken litter can not only be used as fertilizer but also as an adsorbent for the soil to adsorb alkaline cations in the soil system. Although fertilizers are essential in crop growth and yield production, their usefulness partly depends on how their nutrients are absorbed and desorbed. Thus, the ability of the soil to exchange cations (CEC) is very instrumental in the existence of chicken litter. Table 2 shows the CEC of chicken litter is 182.67 cmol(+) kg^{-1}. So, chicken litter can be used as fertilizer and adsorbent simultaneously.

Throughout chicken fattening, droppings, urine, feathers, and spilled feed are deposited on the foundation material, giving the final composition of the chicken litter a high nutritious value. Finally, manures improve soil fertility by supplying nutrients such as nitrogen that microorganisms in the soil can use [51] Considering it is high in organic matter (OM) and nutrients such as nitrogen, phosphorous, and potassium, livestock manure is an essential fertilizer resource for agricultural productivity [52] .

Finally, plant growth has a lot of guarantees for chicken litter. [53] examination of nutrient concentration, organic matter, chlorophyll concentration, and germination index in poultry manure (PM) and human manure from a family primarily eating organic food (HMO) revealed higher potassium and sulfate concentrations, as well as higher C/N ratios, than human manured dan cow manure (CM). Furthermore, the three PM manures contained humic- and fulvic-acid-like compounds. According to the findings, CNM, PM, and HMO have more significant plant development potential.

Such potential significantly impacts the fertility and health of the land so that environmentally friendly and sustainably utilizable land management efforts can be realized. It has been demonstrated that using chicken litter instead of chemical fertilizer is effective and can provide soil and plants with nutrients, increasing the amount of dry matter produced and raising plantation output. In a two-year field study, [54] used chicken litter as one of several fertilizer sources to assess the dry matter production of maize and [55] the growth of eggplant whose soil has been improved with composted poultry litter.

In addition to improving chemical and biological quality in the soil, chicken litter can also be used as additional material to support the physical properties of the soil, especially in maintaining the presence of water and air in the soil. Average and good drainage are determined by the presence of soil pores. This is connected to the density of the soil. To compensate for chicken manure's low porosity, high moisture content, low C/N ratio, and high pH, high C/N ratio bulking agents such as rice husk, wood chips, and sawdust are added. These compounds minimize water content while increasing the C/N ratio, pile porosity, and aeration systems [42]-[46].

Adding chicken litter to the soil is thought to lower its density, allowing for more water and easier mobilization and absorption of dissolved components by plant roots. Improved bulk density, higher aggregate stability, improved porosity, easier cultivation, plant nutrition, penetration, and seedbed preparation are all directly influenced by the organic matter in the soil [45], [46].

However, chicken litter has more potential to function as fertilizer or soil ameliorant because of the many elements and functional groups needed by soil and plants from the analysis of FTIR, SEM-EDS, and physicochemical characteristics in chicken litter. Its potential as a heavy metal adsorbent is more significant if treated again by making it biochar through the pyrolysis process so that it opens the pores and surface area of sawdust in chicken litter.

IV. Conclusion

Chicken litter waste has chemical characteristics that have the potential as a biosorbent and are valuable as fertilizer. Proximate composition (moisture 4.26%; volatile matter 74.20%; ash 6.78% and fixed carbon 14.76%); pH (pH H_2O 8.37 and pH PZC 7.37); electrical conductivity (EC) >2 dS m^{-1} and cation exchange capacity (CEC) 182.67 cmol(+)kg^{-1}. The negative charge of these characteristics opens its ability to absorb cations marked by the CEC value obtained.

The nutrient composition of chicken litter waste in closed-house systems has macro nutrients (6.88% C; 0.06% N; 5.89% P; 34.89% K; 36.28% Ca; 5.76% S) and micronutrients (2.49% Fe; 1.39% Mn; 1.22% Zn; 1.01% Cu; and 5.15% Cl). Chicken manure waste in closed-house systems also has functional groups such as O-H, N-H, C-H, C-OH, C=C, C=O, C-O-C, Si-O, and O-CH3, which play an active role in the absorption of pollutants and nutrients in the soil.

Other treatments for chicken litter to improve its quality are needed so that many benefits can be obtained from using waste in the form of chicken litter. Therefore, its application is not restricted to using it as farmland fertilizer. Thus, further application of chicken litter to the soil must prove its ability as an ameliorant that can improve fertility, soil, and environmental health.

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