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Biofuz: A Takagi Sugeno Fuzzy Expert-Based Rice Straw Enhanced Decomposition System

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ABSTRACT

In this study, a Takagi Sugeno Fuzzy Expert system were developed to monitor the temperature, moisture and nutrient level to enhanced the decomposition of the rice straw. The input parameters of the Fuzzy Expert model that were used such as temperature, nutrient content, availability of oxygen and free moisture. In this study the Takagi Sugeno approach fuzzy expert system for easy monitoring of the temperature, nutrient content, oxygen, moisture and particle size of rice straw to enhanced decomposition were used. Upon conducting the experiments the fuzzy expert system improved the decomposition process as a result of testing where two experiments conducted one with Fuzzy expert system and the other one is the traditional decomposition process, the first experiment obtained 14 days to decompose the rice straw compared to the latter it took 24 days to decomposed the rice straw. It only shows that Fuzzy Inference expert system can be a great tool to monitor the decomposition process.

Key words: About Fuzzy, Expert systems, Rice straw decomposition, Takagi Sugeno approach

1. INTRODUCTION

Current rice cultivation activities leave a significant quantity of wet grain in the field that cannot be used as staple. The rice straw is good for composting [1]. The raw material like rice straw and other livestock waste material can be used into a more decomposed substrate known as compost [2]. Compost is used as a soil enhancer or specifically as a planting tool. The compost products can be applied to improved crop production and added nutrient to the soil[3].

1.1 Composting Material Properties

The waste products in decomposing have been mixed and resulted into a better-quality organic resource. In composting process, the promptness and consistency of the decomposition depends on form, nature and rice straw properties (physical and chemical), the climate affects the process too. Table 1 shows the different raw materials and its properties.

Table 1: Composting Raw Materials and its Properties

Authors	*Raw Material*	Properties					
		pH Level	Total Organic Carbon	Carbon (%)	Nitrogen (%)	C/N ratio	Moisture Content (%)
Jusoh et. Al (2013) [4]	Rice straw	7.6	39.2			61.3	11.4
Qui et.al (2013)[5]				40.2	0.7	55.1	10.2
IRRI (2019) [6]				47.0	1.3	35.3	
	Spent rice straw after mushroom production			14.3	0.7	21.9	
				13.3	0.9	14.3	
	Banana Trunk					39.6	90
Qui et.al (2013)[5]	Sawdust			50.8	0.8	60.4	4.6
Jusoh et. Al (2013)[4]	Green waste	6.5	15.3			8.4	79.0
	Goat manure	7.1	35.6			13.0	58.0
IRRI (2019)[6]	Cow manure			12.9	0.9	14.5	
				11.4	0.8	14.0	
Qui et al. (2013) [5]	Hog manure			15.3	0.9	16.5	53.6

Table 1 shows the different raw materials and its properties. Different researchers conducted studies on different raw materials in composting. Among all raw materials rice straw materials, has the highest pH level, Total Organic Carbon (TOC), C/N or carbon to Nitrogen ratio and Moisture content. One of the factors affecting the decomposition of rice straw were temperature. Temperature was categorized into four phases during composting process such as (1) mesophilic, (2) thermophilic, (3) cooling and (4) maturation. Heat was produced due to decomposition of compound and due to bio-oxidative microbial degradation during the initial phase [2]. The mesophilic bacteria who facilitated the process were less productive when temperature rises to 40 ° C and thermophilic bacteria predominating. At around 55 ° C and degradation of

plant pathogens begin. At 60 ° C and above the full hygienization takes placed. The researchers recommended to avoid temperatures to reached over 65 ° C, due to it might destroy or damage useful microbes [7]. For Three consecutive days temperature must be more than 55 ° C The composting temperature must be more than 55 ° C for to destroy the pathogens. Basically, temperature hits 60 ° C after 10 days and from 60 to 90 days after composting air temperature reduces[4].

Another factor that affects the decomposition was the moisture level. During microbial process, moisture influences the supply of oxygen. In decomposition process water plays a significant role during decomposition and also water is the weakened the behavior of microbes on strong substrates. Nonetheless, the moisture contributes to Anaerobic environment when it reaches 65 per cent, the soil in the pore areas of the raw materials is driven by wind, and slower decomposition [8]. The maximum amount for microbial growth was when the content of the moisture mixture has been held at 60% [9]. Water is applied to the compost throughout the entireprocess to maintain the maximum moisture content of 50–65 per cent (wet basic) of the compost. To avoid unnecessary heat loss and maintain the moisture content upon turning, a plastic sheet is used to cover the windrow [10].

Oxygen supply is an important decomposition parameter for successful development of microbes. Most fungi and bacteria and like other species need air to live when consumes the food available in the rice straw. The volume of oxygen within the bale can easily be depleted and substituted by carbon dioxide during successful microorganism respiration due to the 90% air that the straw substrate had. Decomposition rate would be reduced when the distribution of fresh air into the substrate is hindered. Though not quantified, decomposition rate in the substrate is expected to be greater than the substrate that is exposed to the atmosphere owing to the small quantity of usable oxygen. Temperature is an essential parameter for the development of microorganisms. Such tiny life forms cannot live below 32 ° F (0 ° C) since the water is frozen. Most fungi and bacteria cannot survive at temperatures below 50 ° F (10 ° C) so development is not really successful at low temperatures. Fungi and bacteria can live in the 68 ° F (20 ° C) to 150 ° F (65 ° C) range, with each species providing its own range and optimum growth temperature. Most species cannot live over 150 ° F (65 ° C) and biological development stops. Moisture is the main component that induces straw decomposition, and most people are familiar with the connection between moisture and mold growth [11].

The greener the straw, the more nitrogen level in it. Allowing Too much drying can reduce the level of nitrogen in the rice straw. Since the bale of straw is almost 90% air, the amount of oxygen within the bale can easily be used and substituted by carbon dioxide during active microorganism respiration decomposition.

The proponents proposed a system that will monitor the speedy decomposition process through fuzzy expert system.

The expert systems are effective method to solved the problems in agriculture [12].

2. EXPERT SYSTEM

An expert/knowledge-based framework is a computer program programmed to replicate the decision-making ability of the decision-maker(s) (i.e. the expert(s) in a very limited field of expertise [13]. The key goal of expert machine systems is to ensure that human knowledge is translated into electronic processes. The integration not only aims to maintain individual knowledge, it also encourages people to be freed from the more repetitive tasks that may be synonymous with encounters with a computer-based program. There are other areas that utilize an expert network, such as the gathering of information from specialists in the area of computer diagnostics and the storing of it in an open database where it can be accessed by anyone. Availability of diagnostic knowledge is expected by non-experts [14].

2.1Review of Related Studies

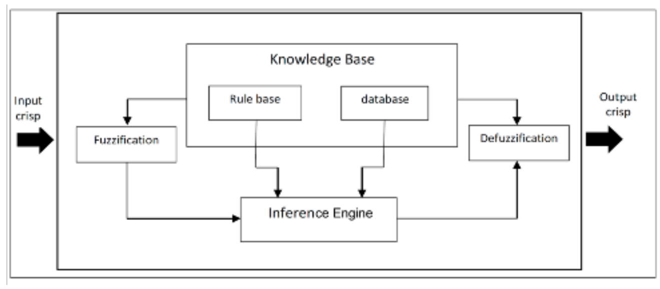

Figure 1: Basic Diagram of an FIS

Figure 1 illustrates the basic block diagram of a Fuzzy Inference System which is made up of three parts, the (1) fuzzification, which transforms the raw value data into a linguistic attribute utilizing the membership functions retained in the knowledge base;(2) inference engine, where the given function of the level of membership of the input parameters to the output of fuzzy sets using the rules in fuzzy. Eventually, the defuzzifier part translates the output to a crisp value.

The Fuzzy Expert method integrates the information and experiences of a specialist in creation of a structure that controls a process of input to output relationship that are represented by a set of fuzzy control laws, e.g. IF – the rules of the otherwise [15]. The logic reasoning of Fuzzy consists of two kinds of information (1)Labels; and (2) membership assignment given to input and output parameters. These relates to the rule-base which processes the fuzzy values of inputs to the fuzzy values of outputs [16]. The Fuzzy framework has been used in various areas, such as profiling. [17], prediction of credibility of loan applicants [18].

3.METHODOLOGY

The proposed FIS system was developed using the following procedures:

3.1 Fuzzy Inference to Measure Enhance Decomposition

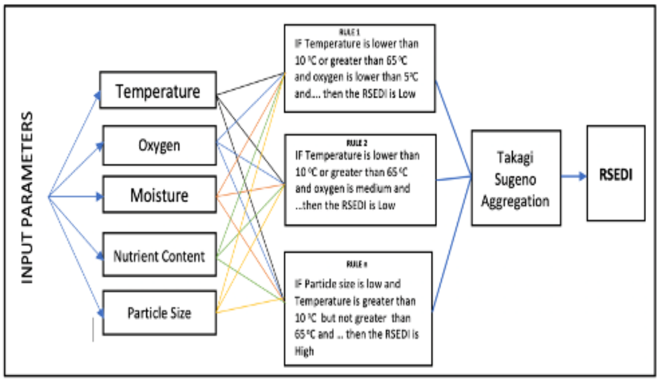

Figure 2: Proposed Fuzzy Inference System for Rice Straw Enhanced Decomposition System Index (RSEDI)

Figure 2 shows the proposed FIS for the design of RSEDI to improve the decomposition process. The method of utilizing fuzzy inference was suggested by the proponents, who calculate the impact of temperatures and work with unknown results. In the model, the proponents identified five parameters: (a) temperature; (b) amount of oxygen; (c) moisture; (d) quality of nutrients; and (e) Particle size or thickness of the rice straw. The speed-up decomposition parameters are temperature, oxygen density, moisture, nutrient content and particle size. Temperature will range from 10 degrees Celsius to 65 degrees Celsius for bacteria and fungi to survive. The moisture must not be too weak, but it must not be too hot. Oxygen content must not be less than 10% or more than 60% will result to anaerobia. The nutrient quality, nitrogen and phosphorus must be present, the greener the higher the nitrogen quality. This would be better for the particle size of a rice straw if the particles were bigger, which is why they need a grinder. The smaller the particle size the faster it would be decayed. Since several experts have specified and modified the parameters and membership functions (MF) that describe the inference model kernel.

Table 2: If-Then Rules applied to Enhance Decomposition

1. If (Temperature is low) and (Oxygen is low) and (Moisture is low) and (Nutrient Content is Good) and (Particle size is Low) then (The decomposition is low)
2. If (Temperature is low) and (Oxygen is low) and (Moisture is low) and (Nutrient Content is Good) and (Particle size is Acceptable) then (The decomposition is low)
3. If (Temperature is low) and (Oxygen is low) and (Moisture is low) and (Nutrient Content is Good) and (Particle size is high) then (The decomposition is low)
4. If (Temperature is low) and (Oxygen is low) and (Moisture is low) and (Nutrient Content is Acceptable) and (Particle size is high) then. (The decomposition is low)
5. If (Temperature is low) and (Oxygen is low) and (Moisture is low) and (Nutrient Content is Bad) and (Particle size is High) then 6. (The decomposition is very low)
....
48. If (Temperature is Medium) and (Oxygen is high) and (Moisture is high) and (Nutrient Content is good) and (Particle size is High) then (The decomposition is Medium)
49. If (Temperature is Medium and (Oxygen is high) and (Moisture is high) and (Nutrient Content is good) and (Particle size is high) then (The decomposition is High)
50. If (Temperature is Medium and (Oxygen is high) and (Moisture is high) and (Nutrient Content is good) and (Particle size is high) then (The decomposition is high)
51. If (Temperature is Medium and (Oxygen is high) and (Moisture is high) and (Nutrient Content is high) and (Particle size is high) then (The decomposition is High)

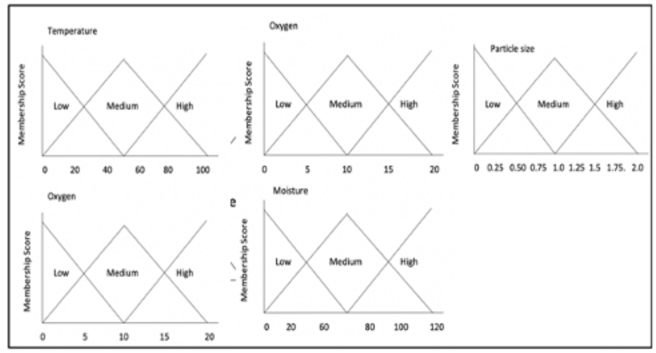

Figure 3: Membership function that affects the decomposition

Figure 3 shows the Membership function of each input parameters such (1) temperature is said to be in low temperature when it is less than 10 ° C, middle or average when it reaches 65 ° C and high temperature when above 65° C; (2) Moisture is said to be in low moisture when it is below 60% and high above 60% to 100%;(3) Oxygen is low when below 5% and medium and average when 10% and high above 20%; (4) Nutrient content, for Nitrogen the greener the better less than 55 pixel is low and medium is 155 and high when it reaches 255;(5) particle size, the smaller the size of the rice straw the better, low or smaller is less than .50 inches , medium at 1 inch and bigger when it is 2.0 inches.

3.2 Hardware Design

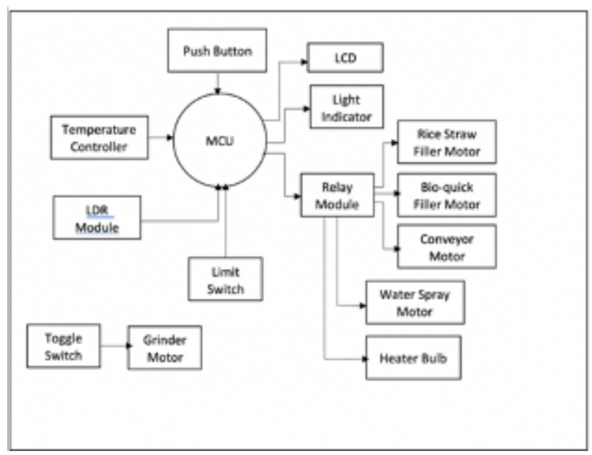

Figure 4: Enhance Rice Straw Decomposition Block Diagram

Figure 4 illustrates the block diagram of the system where the grinder is manually operated. The hardware is consist of push button switches, temperature controller, LDR module, limit switch, toggle switch, LCD, Light indicator, Relay module, heater bulb and different motors for rice straw filler, bio-quick filler, conveyor motor, water spray and Arduino for the mcu. There proponents used Arduino micro-controller with related studies in knock pattern [19] and wireless hand gesture [20]. The Toggle switch manually turns on and off the grinders. When the grinder finished its operations, the push buttons send input signal to the microcontroller to run the system. Temperature controller LDR modules and limit switch are directly connected to the microcontroller. These inputs will trigger the relay for the operations to be performed by the system. The Rice straw filler motor, bio-quick motor, conveyor motor, water spray motor

4.TESTING AND RESULTS

Table 3: Testing Results

Temp	Oxygen	Moisture	Nutrient	particle size	status	Action
9	9	50	83	1	0	Heater turn-on , add bio-quick, add water
10	10	30	171	0.1	1	add water
20	30	70	200	0.25	2	no action
21	31	71	171	2.005	2	no action
22	20	72	172	3.005	2	no action
23	20	90	221	4.005	2	no action
60	19	81	233	0.001	2	no action
25	20	50	80	6.005	0	Add water, add bio-quick, place in grinder
26	36	76	176	7.005	1	add bio-quixk
8	37	90	224	8.005	0	heater turn on
28	38	78	80	0.005	2	add bio-quick
29	39	79	179	10.005	1	place in grinder
30	40	80	180	11.005	1	place in grinder
31	41	81	181	0.002	2	no action
32	42	82	182	13.005	2	place in grinder

Legend:

0-
1- Low speed decomposition
2- Medium speed decomposition
3- High speed (fast) decomposition

Table 3 shows the result of testing the proposed Rice straw decomposition using the Fuzzy inference. When the temperature, oxygen, moisture, nutrient and particle size is low the status of decomposition is low. When 3 out of 5 parameters obtained high, the result of decomposition is high or fast. When all of the parameters were met and satisfy its decomposition is fast. When temperature is medium and two of the parameters were high, the decomposition is fast or high.

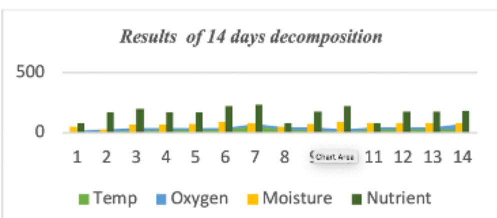

Figure 5: Result of the Proposed FIS to enhance decomposition monitoring

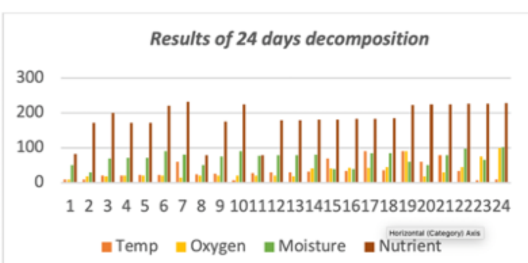

Figure 6: Result of the traditional Decomposition without FIS Decomposition

Figure 5 and figure 6 shows the differences of the results of a decomposition with FIS and traditional without the FIS. The proponents noticed if the Rice straw were not maintained the appropriate temperature, oxygen level, moisture content, Nutrient content the decomposition takes too long compared to the one use with FIS.

5.CONCLUSION AND FUTURE WORK

In this study the proponents proposed a Fuzzy system to improve the decomposition process of a rice straw. The paper offers a scientific method of monitoring the rice straw decomposition for faster decomposition, the parameters such as temperature, oxygen, moisture, nutrient content and particle size of rice straw were monitored to ensure that this will go beyond the required temperature, oxygen, moisture, nutrient content and even particle size of the rice straw. When the temperature reached above 65 degree Celsius the system will be advised that it need to add water to lower the temperature or to improve the moisture content. When the Nutrient content is lower, the system displayed that it needs to add bio-quick to improve nitrogen content. Two experiments were conducted one rice straw decomposition uses the FIS to monitor its decomposition status and the other one was the traditional without FIS. As a result, the rice straw wit FIS decompose for 14 days while the traditional is 24 days.
Therefore, the proponents can conclude that in order to have a faster decomposition an FIS system will be a great help to improve the decomposition process of rice straw due to strict monitoring and prompt response.
For future works the system can be improved by adding neural network or artificial intelligence techniques.

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REFERENCES

1. N. Nghi et al., **Rice Straw-Based Composting,** *Sustainable Rice Straw Management*, pp. 33-41, 2019.
2. H. Insam and M. de Bertoldi, **Chapter 3 Microbiology of the composting process**, *Compost Science and Technology*, pp. 25-48, 2007.
3. M. Diacono and F. Montemurro, **Long-Term Effects of Organic Amendments on Soil Fertility**, *Sustainable Agriculture Volume 2*, pp. 761-786, 2011.
4. M. Jusoh, L. Manaf and P. Latiff, **Composting of rice straw with effective microorganisms (EM) and its influence on compost quality**, *Iranian Journal of Environmental Health Science & Engineering*, vol. 10, no. 1, 2013.
5. J. Qiu et al., **Effects of Conditioners on Sulfonamides Degradation during the Aerobic Composting of Animal Manures**, *Procedia Environmental Sciences*, vol. 16, pp. 17-24, 2012.
6. [N. Nghi et al., **Rice Straw-Based Composting**, *Sustainable Rice Straw Management*, pp. 33-41, 2019. Available: 10.1007/978-3-030-32373-8_3 [Accessed 28 April 2020].
7. V. Nguyen et al., **Generating a positive energy balance from using rice straw for anaerobic digestion**, *Energy Reports*, vol. 2, pp. 117-122, 2016.

8. S. Shilev, M. Naydenov, V. Vancheva and A. Aladjadjiyan, **Composting of Food and Agricultural Wastes**, *Utilization of By-Products and Treatment of Waste in the Food Industry*, pp. 283-301.
9. E. Rudnik, **Composting methods and legislation**, *Compostable Polymer Materials*, pp. 127-161, 2019.
10. S. Goyal and S. Sindhu, **Composting of Rice Straw Using Different Inocula and Analysis of Compost Quality**, *Microbiology Journal*, vol. 1, no. 4, pp. 126-138, 2011.
11. S. Vigneswaran, J. Kandasamy and M. Johir, **Sustainable Operation of Composting in Solid Waste Management**, *Procedia Environmental Sciences*, vol. 35, pp. 408-415, 2016. https://doi.org/10.1016/j.proenv.2016.07.022
12. S. Cascone, R. Rapisarda and D. Cascone, **Physical Properties of Straw Bales as a Construction Material: A Review**, *Sustainability*, vol. 11, no. 12, p. 3388, 2019. https://doi.org/10.3390/su11123388
13. Y. Shang, **Expert Systems**, *The Electrical Engineering Handbook*, pp. 367-377, 2005. https://doi.org/10.1016/b978-012170960-0/50031-1
14. Shu-Hsien Liao, **Expert system methodologies and applications—a decade review from 1995 to 2004**, *Expert Systems with Applications*, vol. 28, no. 1, pp. 93-103, 2005. https://doi.org/10.1016/j.eswa.2004.08.003
15. J. Guanzon, **An Expert System Optimization Model for Desktop Computers**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 3, pp. 676-682, 2019. https://doi.org/10.30534/ijatcse/2019/54832019
16. F. Camastra et al., **A fuzzy decision system for genetically modified plant environmental risk assessment using Mamdani inference**, *Expert Systems with Applications*, vol. 42, no. 3, pp. 1710-1716, 2015. https://doi.org/10.1016/j.eswa.2014.09.041
17. C. Escolar-Jimenez, **Intelligent Shortlisting Process for Job Applicants Using Fuzzy Logic-Based Profiling**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 3, pp. 567-572, 2019. https://doi.org/10.30534/ijatcse/2019/36832019
18. S. P M, **A Fuzzy based Data mining Approach for the Loan Credibility Prediction System in Co-operative Banking Sector**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 3, pp. 815-820, 2019. https://doi.org/ 10.30534/ijatcse/2019/74832019
19. A. Alon, **SmaCk: Smart Knock Security Drawer Based on Knock-Pattern using Piezo-electric Effect**, *International Journal of Emerging Trends in Engineering Research*, vol. 8, no. 2, pp. 339-343, 2020. https://doi.org/10.30534/ijeter/2020/16822020
20. A. Alon and J. Susa, **Wireless Hand Gesture Recognition for an Automatic Fan Speed Control System: Rule-Based Approach**, *2020 16th IEEE International Colloquium on Signal Processing & Its Applications (CSPA)*, 2020. https://doi.org/10.1109/cspa48992.2020.9068687