Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

Special Issue

DEGRADATION OF PARTICLEBOARD MADE USING GLUTARDIALDEHYDE MODIFIED CORN STARCH AS THE BINDER BY SOIL AND SOIL INHABITING ORGANISMS

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Published online: 1 February 2018

ABSTRACT

This study evaluates the weight loss of experimental particleboard panels made from *Hevea brasiliensis*) using modified starch as binder after contact with soil. Panels were manufactured using 15% native corn starch, 15% corn starch modified with citric acid, 13% modified starch with 2% urea formaldehyde resin, 15% corn starch modified with glutardialdehyde and 13% modified starch with 2% Urea Formaldehyde as improvement. Using citric acid modified corn starch as the binder showed less influence on the weight loss of particleboards after contact. Results found that the 2% replacement of modified starch with urea formaldehyde resin made some of the particleboard showed reduction in the degradation of the particleboards made using glutardialdehyde modified corn starch as the binder.

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doi: http://dx.doi.org/10.4314/jfas.v10i2s.54

Particleboard made using urea formaldehyde as the binder always showed the lowest weight loss.

Keywords: wood; starch; particleboard; composite; soil burial.

1. INTRODUCTION

Utilization of woody material waste in wood composite making had started around 40 years ago [1]. Among them were the chipboard, fibreboard, cement board, particleboard and the latest are wood plastic composites. Wood composite technology make the utilization of wood more efficient as small pieces of wood from sawmilling, solid wood furniture industry and tree branches after logging activity as well as from municipal waste can be used produce more valuable products.

As the formaldehyde emission from particleboards made using formaldehyde based binder drew a lot of attention from the society, alternative adhesives were explored to replace or at least reduced the utilization of those adhesives. Formaldehyde emission from the manufactured panels was believed could cause trigger cancer cell in human being. Environmental friendly products are in growing demand nowadays. Research is now more towards something renewable, recyclable, sustainable and triggered biodegradable. The development of commercially viable 'green products' based on natural resources are on the rise [2]. Starch is one of the natural polymers that had been explored to be used in various fields such as biodegradable polymer and adhesives. Utilization of starch as an adhesive or binder has several drawbacks such as long setting time, low resistance to moisture and microorganisms. Thus, many researchers had done chemical modification on the starch to transform it into a more reliable polymer.

Currently, there are many chemicals that are commercially used to treat wood to enhance its resistance to biodegradation and to extend its service life under the environmental conditions. At the same time, both health and pollution concerns of these preservative chemicals are getting more concern. Therefore, researchers were trying to develop environmentally friendly chemicals with satisfactory properties. This paper works on evaluation of weight loss of particleboards made using citric acid modified corn starch as the binder after soil burial test [3].

2. METHODOLOGY

A Rubberwood (Hevea brasiliensis) particle was supplied by a local particleboard company, Heveaboard in Negeri Sembilan, Malaysia. Obtained wood particles were dried to 2% moisture content in a laboratory type oven. Modification of corn starch using citric acid was done following the method by [4]. About 100g of corn starch was mixed with 250 ml of distilled water and stirred constantly inside a 50 ˚C water bath. Approximately, 10g of citric acid was added into the starch solution and sodium hypophosphite was mixed at 50 % w/w on the weight of citric acid used. The temperature of waterbath was raised to 90˚C with stirring continued until resinification was attained. Citric acid modified starch was used in thick liquid form for particleboard making.

Corn starch in powder form modified with glutaraldehyde in liquid form in a ratio of 1:2 (w/w) was used as binder in a ratio of 15% based oven dry particle weight. Commercial urea formaldehyde resin was obtained from Hexion Specialty Chemical Company based in Penang, Malaysia. Glutardialdehyde (GDA) is a colorless oily liquid organic compound with the formula of CH_2 $(CH_2CHO)_2$ and usually used as disinfector agent for medical equipment with specific density ranging from 1.06 to 1.12 at 20 ˚C [5]. Corn starch powder was dissolved in distilled water with a temperature of 30˚C. Mixture was stirred with overhead stirrer with temperature controlled by waterbath heating. Temperature was increased slowly and 25% glutardialdehyde solution was added at 60 ˚C. Mixture was stirred continuously until resinification was attained [3].

A total of 60 panels, pentaplicate for each density level with dimension of 20.1 cm by 20. 1 cm by 0.5 cm was manufactured for the experiments [6] as shown in Table 1. Panels were made for target density levels of 0.60 g/cm^3, 0.70 g/cm^3 and 0.80 g/cm^3. Rubberwood particles was mixed with 15% modified corn starch before they were processed in a hotpress using a pressure of 5 MPa at a temperature of 165˚C for 20 min. Panels were conditioned in a climate chamber with a temperature of 20±2˚C and a relative humidity of 65±5% for 2 weeks [7-8].

Table 1. List of particleboard types made

Particleboard Binder Type	Target Density (g/cm^3)
Corn starch	0.60
	0.70
	0.80
Urea formaldehyde	0.60
	0.70
	0.80
Citric acid modified corn starch	0.60
	0.70
	0.80
Citric acid modified corn starch with 2% urea formaldehyde	0.60
	0.70
	0.80

2.1. Resistance against Soil Inhabiting Microorganism

This test was done to evaluate the durability of particleboard towards natural decaying agents in soil. Water holding capacity (WHC) was first determined following British Standard [9]. Then, it was followed by determination of the amount of water percentage from the mass of specimen taken required to raise moisture content of substrate.

Soil substrate was commercially obtained from a local company in Penang, Malaysia. The soil has pH value of 6.7 and free from agro-chemicals. Water holding capacity of soil was determined using the previously described method and showing 55 % of water holding capacity. The soil was screened through a sieve of nominal aperture size of 12.5 mm and stored in sealed plastic bags. Test pieces of 100±0.5 mm × 10±0.1 mm × 5±0.1 mm were cut from the particleboards and conditioned at 20±2°C with 65±5% relative humidity.

Glass aquarium was used as test arena. Mass of soil substrate required to provide at least 120 mm depth of substrate was prepared and the amount of water required to bring the substrate in the fully charged arena to 95 % of its WHC. Required volume of substrate was added to the test arena and calculated amount of water was added slowly with thorough mixing to ensure even distribution of moisture in the substrate.

Test specimens were vertically planted with 20 mm of their length were above soil level with a minimum of 20 mm between adjacent specimens and from the sides of the arena. Charged test arenas were transferred to the culture chamber and incubated for 4 weeks and 8 weeks at 27 ±2 °C of temperature and 70±5% relative humidity. Test arenas were kept in the dark and protected from light.

Before incubation, the charged test arena and lid were weighed to the nearest 5 g and the initial mass was recorded. Test specimens were weighed for its initial mass (m_0). After 4 weeks incubation, the test arena were removed and reweighed. Loss of weight was topped up with required amount of water. At the end of incubation, Test specimens were taken out, cleansed from adhering soil. The specimens were dried for 18 h to 24 h in a 103±2 °C oven and cooled to room temperature in a desiccator. Each specimen was weighed to the nearest 0.001 g and the final dry mass (m_3) was recorded. Loss of mass was calculated using Equation (1).

$$Weight\ loss, \% - \frac{m_0 - m_3}{m_0} \times 100 \qquad (1)$$

3. RESULTS AND DISCUSSION

Fig. 1-2 showed the weight loss of manufactured particleboards after 4 weeks and 8 weeks of soil burial of particleboard specimen respectively. Difference in particleboard densities did not affect the weight loss of the specimens after 4 weeks and 8 weeks. At all density level, particleboard made using urea formaldehyde as the binder showed the lowest weight loss, mainly because the chemical inside the binder is more resistance to microbes and moisture [10]. Table 2 showed the statistical analysis of particleboards made, showing no significant difference when compared between different densities in general. The water holding capacity of the soil affects the weight loss of the specimens, besides the amount of microorganisms inside the soil.

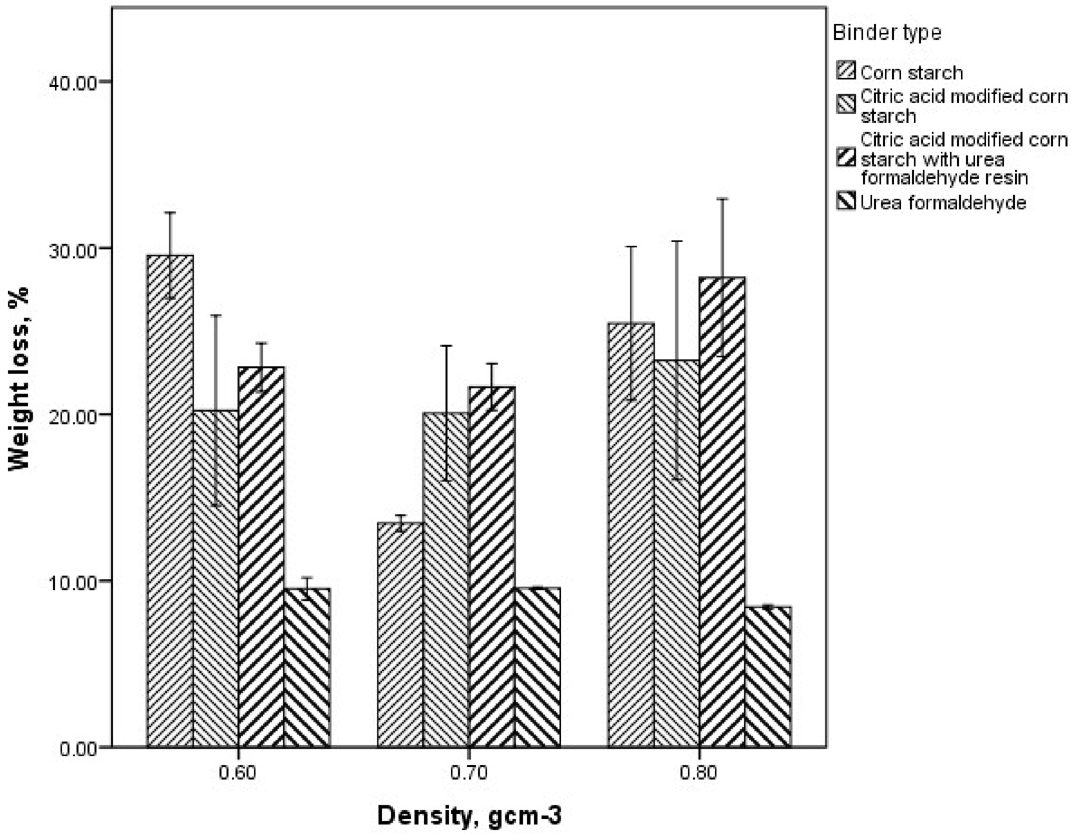

Fig.1. Weight loss of particleboards after 4 weeks exposure to soil

Table 2. Statistical analysis of particleboards made, compared between different densities

Panel Type	Target density	Soil Burial Test, Decay (%)	
	(g/cm^3)	4 Weeks	8 Weeks
Corn starch	0.60	29.55	32.62
		(3.34)a	(5.95)a
	0.70	13.46	45.96
		(0.60)b	(11.84)b
	0.80	25.46	32.50
		(6.00)a	(7.93)a
Urea formaldehyde	0.60	9.52	14.63
		(0.86)a	(5.98)a
	0.70	9.56	11.46
		(0.09)a	(2.65)b
	0.80	8.43	17.29
		(0.15)b	(0.69)c
Citric acid modified corn starch	0.60	20.23	32.40
		(7.44)a	(3.95)a
	0.70	20.07	38.83
		(5.28)a	(10.71)a
	0.80	23.24	49.63
		(9.32)a	(7.12)b
Citric acid modified corn starch with	0.60	22.82	36.77
2% urea formaldehyde		(1.89)a	(13.68)a
	0.70	21.65	42.20
		(1.82)a	(9.86)a
	0.80	28.21	51.11
		(6.16)b	(7.11)b

*different letter in a same column and same type of binder shows significant difference at α value of 0.05

After 8 weeks of soil burial, the particleboards made using urea formaldehyde as the binder still showed the least weight loss at all density levels. After 8 weeks of exposure, the weight loss are considerably higher at higher density levels. Statistical analysis showed no significant difference when compared to different density levels. However, increasing soil burial duration do increases specimen weight loss. At 4 weeks of soil burial, the highest weight loss was shown by particleboard made using corn starch as the binder which is 29.55%. While at 8 weeks of exposure, the highest weight loss was shown by particleboard made using citric acid modified corn starch with 2% urea formaldehyde as the binder that showed 51.11% weight loss.

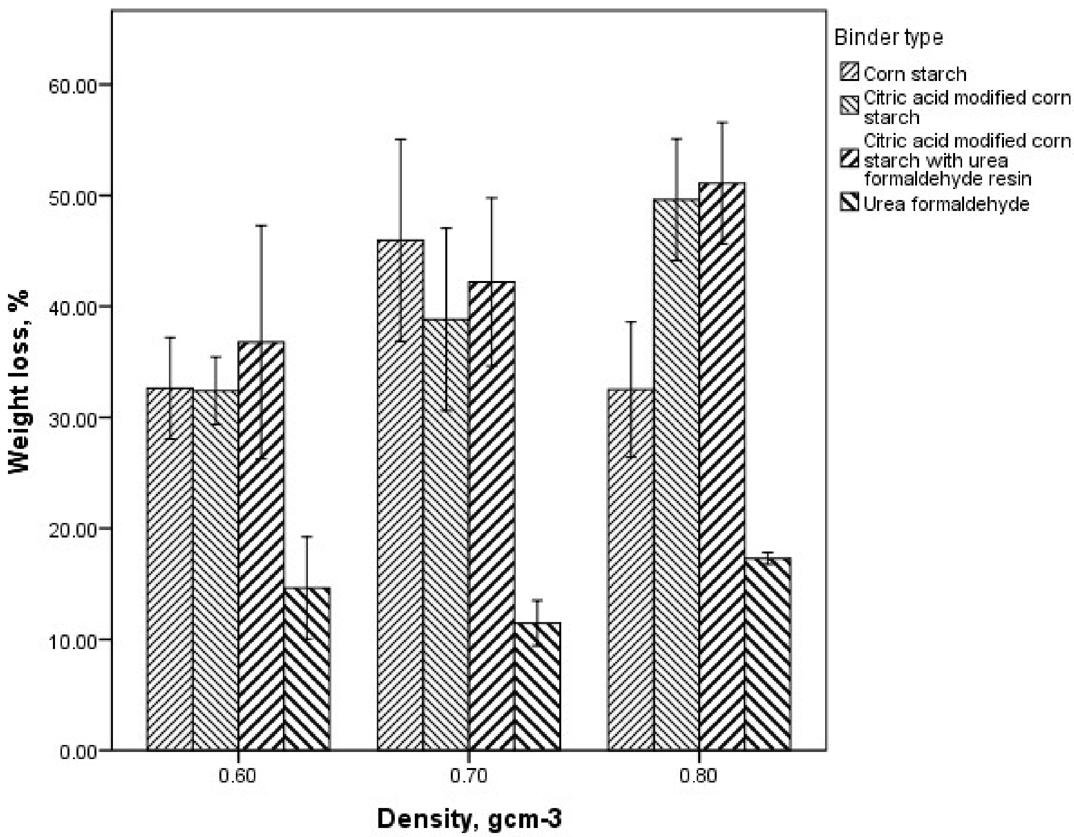

Fig.2. Weight loss of particleboards after 8 weeks exposure to soil

Fig. 3-4 showed the degradation of manufactured particleboards after 4 weeks and 8 weeks of soil burial of particleboard sample respectively. The degradation degree were having not much difference when compared to different densities, neither after 4 weeks of soil burial nor 8 weeks of soil burial study. Table 3 showed the statistical analysis of particleboards made, showing no significant difference when compared between different densities. Degradation of samples depends on the amount of microorganism available and the condition of the soil itself, mainly the water holding capacity of the soil [11]. However, increasing soil burial time do increases sample degradation. After 4 weeks, all particleboards made using corn starch as the binder showed higher degradation compared to other particleboard type except for density level of 0.60 g/cm^3. The lowest degradation was recorded by particleboards made using urea formaldehyde as the binder, recorded at 8.34% of degradation, followed by particleboards made using glutardialdehyde modified corn starch with 2% urea formaldehyde as the binder and particleboard made using glutardialdehyde modified corn starch only as the binder.

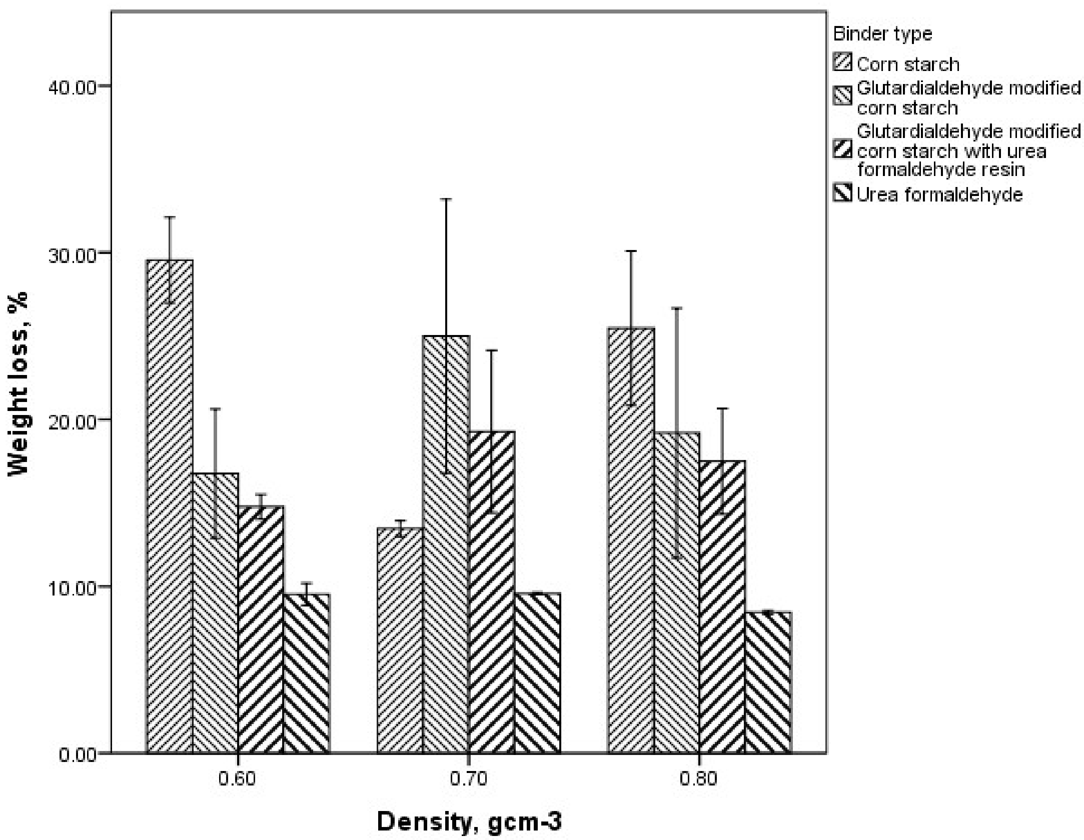

Fig.3. Weight loss of particleboards after 4 weeks exposure to soil

Table 3. Statistical analysis of particleboards made, compared between different densities

Panel Type	Target Density (g/cm^3)	Soil Burial Test, Decay (%) 4 Weeks	Soil Burial Test, Decay (%) 8 Weeks
Corn starch	0.60	29.55 (3.34)a	32.62 (5.95)a
	0.70	13.46 (0.60)b	45.96 (11.84)b
	0.80	25.46 (6.00)a	32.50 (7.93)a
Urea formaldehyde	0.60	9.52 (0.86)a	14.63 (5.98)a
	0.70	9.56 (0.09)a	11.46 (2.65)b
	0.80	8.43 (0.15)b	17.29 (0.69)c
Glutardialdehyde modified corn starch	0.60	16.75 (5.03)a	35.32 (11.67)a
	0.70	24.99 (10.69)a	27.09 (8.26)a
	0.80	19.19 (9.73)a	17.27 (5.90)b
Glutardialdehyde modified corn starch with 2% urea formaldehyde	0.60	14.76 (0.96)a	29.70 (5.02)a
	0.70	19.27 (6.32)a	33.02 (4.84)a
	0.80	17.49 (4.12)a	29.05 (3.19)a

*different letter in a same column and same type of binder shows significant difference at α value of 0.05

After 8 weeks of soil burial, the utmost degradation was shown by particleboard made using corn starch as the binder showed considerably higher degradation level than the others except for particleboard made at 0.60 g/cm^3 density level. At 8 weeks of exposure, pattern of increasing or decreasing were less seen but the particleboards made using urea formaldehyde resin as the binder showed lowest degradation at all density levels.

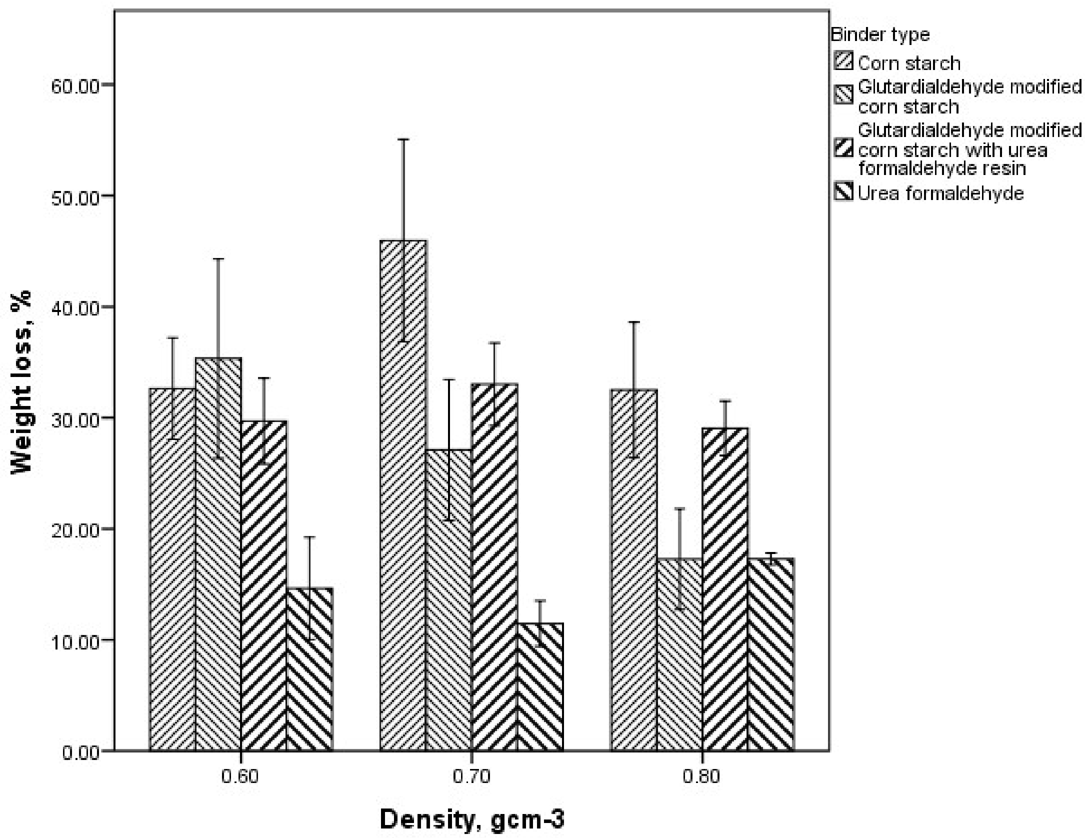

Fig.4. Weight loss of particleboards after 8 weeks exposure to soil

4. CONCLUSION

Using citric acid modified corn starch as the binder showed less influence on the weight loss of particleboards after contact with both after 4 weeks and 8 weeks of exposure. Addition of 2% urea formaldehyde resin did not help to reduce the weight loss as shown in the results. Particleboard made using urea formaldehyde as the binder always showed the lowest weight loss. Further research on higher amount of urea formaldehyde addition should be conducted to produce a type of particleboard that is balance between its high weight loss resistance and environmental friendly properties.

5. ACKNOWLEDGEMENTS

The authors acknowledged Ministry of Education for Research Acculturation Grant Scheme (R/RAGS/A08.00/01046A/002/2015/000302) for Mohd Hazim Mohamad Amini and Universiti Sains Malaysia for the Research University Grant (1001/PTEKIND/815066) to Rokiah Hashim. Appreciation was also given to the Heveaboard Sdn Bhd for providing the raw materials for particleboard making.

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How to cite this article:
Amini M H M, Hashim R, Sulaiman N S, Hiziroglu S, Sulaiman O, Mohamed M, Masri M N, Bakar M B A. Degradation of particleboard made using glutardialdehyde modified corn starch as the binder by soil and soil inhabiting organisms. J. Fundam. Appl. Sci., 2018, *10(2S), 745-757*.