**ТЕХНОЛОГИЯ НЕОРГАНИЧЕСКИХ ВЕЩЕСТВ / TECHNOLOGY OF INORGANIC SUBSTANCES**

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# MYANMAR AGRICULTURAL WASTES PROCESSING BY USING THE METHOD OF PYROLYSIS TO PRODUCE NEW NANO SORBENTS FOR ENVIRONMENTAL POLLUTION CONTROL

Research article

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**Abstract**

In developing countries, such as Myanmar, agricultural waste management has become a challenging issue for the government due to the lack of an efficient planning tool. In these countries, farmers burn agricultural waste in the fields after each harvesting season to address the issue. As a result, this practice has caused air and water pollution in rural areas. In this paper, we present a transformation plan for these waste materials into valuable carbon-based sorbents to combat air and water pollution caused by industrial discharge. This is not the only purpose of this paper; there are many fields in which these carbon-based sorbents (activated carbon) can be used, such as in medicine, food processing technologies, beverages, and deodorizing cooking oil. The pyrolysis and steam activation processes for the production of activated carbon are the simplest and most traditional methods; however, their effectiveness and economic benefits are incomparable to other methods, such as chemical activation. Obtaining the necessary raw materials and their prices is one of the vital problems. We are using the waste products from harvesting, and according to the records of the country's harvesting amounts, these can be arranged for all seasons. In these articles, we are showing the properties of sorption after pyrolysis and activation process. More than that, this paper is concluded by showing the advance usage of obtaining carbon base sorbent from many kinds of agricultural waste from Myanmar by eliminating the impurities which cannot allow into water body by fishery. For these purposes, the authors acknowledge the effectiveness of optimum condition for pyrolysis and water vapour activation for example burning rate, ultimate temperature, isothermal holding time and so no. According to this optimum condition, we are carrying out the analysis for technical indication values such as water vapour absorption, gas absorption and their output. Therefore, in this paper, all of the authors are analyzing and studying how to obtain carbon-based sorbents from various agricultural wastes with proper qualities.

**Keywords:** agri-waste treatment, pyrolysis, steam vapour activation, rice husk, tamarind fruit shell, mango seed shell and iron woods.

# ПЕРЕРАБОТКА СЕЛЬСКОХОЗЯЙСТВЕННЫХ ОТХОДОВ ИЗ МЬЯНМЫ МЕТОДОМ ПИРОЛИЗА ДЛЯ ПОЛУЧЕНИЯ НОВЫХ НАНОСОРБЕНТОВ ДЛЯ БОРЬБЫ С ЗАГРЯЗНЕНИЕМ ОКРУЖАЮЩЕЙ СРЕДЫ

Научная статья

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**Аннотация**

В развивающихся странах, таких как Мьянма, управление сельскохозяйственными отходами стало сложной проблемой для правительства из-за отсутствия эффективного инструмента планирования. В этих странах фермеры сжигают сельскохозяйственные отходы на полях после каждого сезона сбора урожая, чтобы решить эту проблему. В результате эта практика привела к загрязнению воздуха и воды в сельской местности. В данной статье мы представляем план преобразования этих отходов в ценные сорбенты на основе углерода для борьбы с загрязнением воздуха и воды, вызванным промышленными выбросами. Это не единственная цель данной статьи; Существует множество областей, в которых эти сорбенты на основе углерода (активированный уголь) могут быть использованы, например, в медицине, технологиях пищевой промышленности, напитках и дезодорировании растительного масла. Процессы пиролиза и активации паром для получения активированного угля являются наиболее простыми и традиционными методами; Однако их эффективность и экономический эффект несопоставимы с другими методами, такими как химическая активация. Получение необходимого сырья и цены на него – одна из жизненно важных проблем. Мы используем отходы сбора урожая, и согласно записям об объемах сбора урожая в стране, они могут быть распределены на все сезоны. В этой статье мы показываем свойства сорбции после пиролиза и процесс активации. Более того, в этой статье показано эффективное использование сорбента углеродной основы из многих видов сельскохозяйственных отходов из Мьянмы путем устранения примесей, которые не могут попасть в водоем при рыболовстве. Для целей диссертации авторы признают эффективность оптимальных условий для пиролиза и активации водяного пара, таких как скорость забурливания, предельная температура, изотермическое время удержания и т.д. В соответствии с этими условиями мы проводим анализ технических показателей, таких как поглощение водяного пара, поглощение газов и их выход. Поэтому в данной работе все авторы анализируют и изучают, как получить сорбенты на основе углерода из различных отходов сельского хозяйства с надлежащими качествами.

**Ключевые слова:** переработка сельскохозяйственных отходов, пиролиз, активация паром, рисовая шелуха, скорлупа плодов тамаринда, скорлупа семян манго и железная древесина.

**Introduction**

Among Southeast Asian countries, Myanmar has a huge land area and a wide variety of growing conditions, with more than 65 million hectares of terra firma. However, only about 20 percent of this land area (12.6 million hectares) is actually used for agriculture. To put this in perspective, Vietnam uses almost the same amount of land for agriculture despite being only half the size of Myanmar. The most common crops are rice, beans and pulses, and maize, in that order [1]. Myanmar's agricultural sector is an important component of its economy, contributing significantly to GDP, employment, and exports. In terms of financial figures, the agricultural sector's gross domestic product (GDP) contribution was reported to be nearly 24.53 trillion Myanmar kyat in 2020 [2]. Production volume of main crops including rice, coconut, sugar cane and cotton seeds in Myanmar has 376,93 million metric tons [3] in 2022. This is why, agriculture sector also plays a vital role in export earnings, generating about 25% to 30% of total exports. The agricultural sector accounts for approximately **32% to 60%** of Myanmar's GDP, as 37.8% according to the United Nations Food and Agriculture Organization [4]. This figure reflects the sector's importance not only in terms of economic output but also as a primary source of income for many households in Myanmar. Overall, the agricultural sector remains the backbone of Myanmar's economy, providing livelihoods and sustaining the majority of the population. However, lack of waste management processing from all these kinds of agricultural products has become a challenging issue for rural planners due to the lack of an efficient planning tool. In the countries, farmers burnt agricultural waste at fields after each harvesting season to solve the issue. As a result, it has caused air and water pollution in the rural areas of the countries. In this paper, the authors present some modeling scheme for agricultural waste burning (also known as pyrolysis) and production of new nanomaterials such as activated carbon from agri-based waste products, that aims to stop burning waste in open environment and helps to solve anti-pollution problem.

Nowadays, processing for the huge amount of agricultural waste management is lacking in Myanmar. There are some other ways to solve this problem, such as the production of bio-fertilizer, food production for animal feeding, and the production of cooking fuel as a replacement for wood, and so on. Among these, some methods are expensive and face technical difficulties, but the production of activated carbon is more beneficial than the aforementioned methods because of its properties that help treat environmental pollution and improve the country's income by selling the products in the global market. Therefore, in this paper, the authors are working to more effectively support the country’s economy and ecological sector by producing activated carbon from agricultural waste.

**Research metod and experimental**

Pyrolysis is the thermal decomposition of organic matter in the absence of oxygen [7]. The pyrolysis process conditions can significantly affect the physicochemical properties, quality, and yield of the pyrolyzed products such as solid, liquid and gaseous fuels [8], [9]. Thus, the pyrolysis process can be modified to enhance the yield of pyrolytic products, as the process parameters are crucial in determining and enhancing the final quality and quantity of the output. Due to its versatility, ease of use, and upgradeability, most studies have focused on producing oil from biomass pyrolysis, while considering the solid char as waste that could be combusted to provide energy for pyrolysis. The heating rate affects the composition of pyrolytic products. Higher heating rates induce fragmentation that increases oil and gas yield, whereas lower heating rates induce secondary pyrolysis stages and favour char production [10]. In fast pyrolysis, heating rates vary from 10 to 200 ºC/min, and it usually favours liquid and gas products. Whereas slow pyrolysis occurs at a lower heating rate of 0.1–1 ºC/min and the longest residence time yielded solid products, biochar up to 70–80 wt% of biochar at the lower temperature range of 300–500 ºC [11]. Increasing the heating rates from 30 to 50ºC with a concurrent rise in temperature from 400 to 500ºC reduced the yield of biochar [12]. Heating rates also affect the surface morphology of biochar, which is similar to the temperature effect. Surface area and pore volume decrease with increasing heating rates due to the higher evaporation of volatile matters. Similarly, the change in heating rate from 10 to 30ºC at a similar temperature affects the biochar yield. Still, it has less effect on the composition of biochar and other properties. In work [13] noticed the 4–5% variation in the biochar yield at various temperature and no effect on C% in biochar for biomass pyrolysis. Higher heating rates were also associated with reduced oxygen content within the biochar. With the changes in surface characteristics and other physical properties, the application of biochar changes. It is of importance to find the optimum heating rate to produce the biochar for a particular application.

In works [14], [15], [16], authors are emphasizing the variation of heating temperature, heating rate, isothermal holding time for rational condition of each agricultural waste raw materials such as tamarind fruit shell, mango seed shell, iron wood and rice husk. Ways to obtain optimum conditions for better carbonizites and activated carbons are described in table [1].

Table 1 - Parameters of optimum conditioning for pyrolysis and activation

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| Raw materials | Burning rate (°C/min) | Ultimate temperature (°C) | Isothermal Time Excerpts (min) | Vapour consumption (г/г) |
|---|---|---|---|---|
| RH | 10 | 600 | 60 | - |

| Raw materials | Burning rate (°C/min) | Ultimate temperature (°C) | Isothermal Time Excerpts (min) | Vapour consumption (r/r) |
|---|---|---|---|---|
| | 10 | 750 | - | 5 |
| TFS | 10 | 450 | 180 | - |
| | 10 | 700 | - | 5 |
| PS | 10 | 550 | 60 | - |
| | 10 | 800 | 90 | 5 |
| IW | 15 | 550 | 60 | - |
| | 10 | 850 | 60 | 5 |

*Note: in the table, upper row prefers to carbonizates and lower row prefers to activated carbon*

After using these optimum conditions, the sorption properties of carbonizates and activated carbons are analyzed. The obtained results are shown in table 2.

Table 2 - Technical Indicators of activated carbons and carbonisates based on Myanmar agricultural waste

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| Type | I (mg/g) | MB (mg/g) | $V_\Sigma$ ($cm^3/g$) | Vs ($cm^3/g$) | | | output (%) |
|---|---|---|---|---|---|---|---|
| | | | | $C_6H_6$ | $CCL_4$ | $H_2O$ | |
| RH | 787.8 | 560.0 | 1.28 | 0.15 | 0.05 | 0.07 | 40.5 |
| | 285 | 66 | 0.87 | 0.11 | 0.06 | 0.11 | 24.8 |
| TFS | 711.2 | 364.84 | 0.9 | 0.04 | 0.23 | 0.17 | 65.5 |
| | 420.1 | 331.89 | 0.7 | 0.04 | 0.01 | 0.11 | 67.4 |
| PS | 665.5 | 47.9 | 1.21 | 0.26 | 0.24 | 0.24 | 40.8 |
| | 348.8 | 3.9 | 0.87 | 0.16 | 0.05 | 0.13 | 23.3 |
| IW | 1009.0 | 217.0 | 1.7 | 0.8 | 0.67 | 0.18 | 46.0 |
| | 416 | 1.79 | 0.72 | 0.2 | 0.04 | 0.14 | 28.1 |

Table 2 shows that the vapor adsorption values of $C_6H_6$, $CCL_4$ and $H_2O$ increase after the steam activation of each carbonisate and the degree of removal of iodine (I) and methyl blue (MB)from the aqueous solution. The output values are shown in the upper row for activated carbons from carbonisates, and in the lower row for carbonisates from raw materials. Until recently, the task of deep treatment of wastewater from the territory of coke and by-product production remained relevant in JSC Moskoks, authors are using the as sample water for the purpose of testing the functioning of obtaining activated carbon from the agricultural waste of Myanmar. The composition of the sample water is characterized by the data in Table 3 [17].

Table 3 - Characteristics of wastewater discharge No 1 of the Moscow Coke and Gas Plant (numerator and denominator – data of adjacent years)

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| № | Index | MPC*, mg/l | Number of analyses | Above MPC | Content, mg/l | | |
|---|---|---|---|---|---|---|---|
| | | | | | average | min | max |
| 1 | pH | 6.5-8.5 | 21/24 | 0/4 | 7.5/7.3 | 7.0/2.0 | 8.1/10.5 |
| 2 | phenols | 0.001 | 21/24 | 21/24 | 0.09/0.15 | 0.004/0.02 | 0.29/1.69 |
| 3 | Petroleum products | 0.05 | 21/24 | 21/24 | 1.49/1.94 | 0.28/0.19 | 7.95/5.10 |
| 4 | Dry residue | 1000 | 21/24 | 18/16 | 1853/1347 | 551/447 | 3670/5228 |
| 5 | Cyanides | 0.05 | 21/24 | 1/7 | 0.01/0.05 | 0.00/0.00 | 0.08/0.23 |
| 6 | Total iron | 0.10 | 21/24 | 21/24 | 2.67/4.33 | 0.62/0.13 | 7.69/13.53 |
| 7 | Chlorides | 300 | 21/24 | 15/7 | 516/301 | 73/42 | 1644/1650 |
| 8 | transparency | No < 13 | 21/24 | 2/3 | 18/18 | 8/3 | 25/28 |

| № | Index | MPC*, mg/l | Number of | Above MPC | Content, mg/l | | |
|---|---|---|---|---|---|---|---|
| | | | | | average | min | max |
| 9 | Suspended solids | 10.75 | 21/24 | 21/22 | 43.0/89.6 | 11.0/2.3 | 262.0/526.9 |
| 10 | Ammonium nitrogen | 0.40 | 21/24 | 21/22 | 6.4/4.56 | 1.9/0.3 | 24.3/11.2 |
| 11 | Sulfates | 100 | 21/24 | 21/21 | 406/222 | 108/31 | 941/453 |

*Note: maximum permissible concentration of water bodies for fishery purposes*

Deep extraction of organic pollutants from aqueous solutions is known by sorption methods using activated carbons and carbon adsorbents related to them in nature in the form of a variety of cokes, semi-cokes and other carbon-containing materials [18], [19]. Active carbons of industrial production are quite expensive products, the use of which for the extraction of pollutants in water in low concentrations, due to the laws of sorption equilibrium, requires increased consumption of these adsorbents. This circumstance determines the expediency of assessing the rationality of using the activated carbon with 2-3 mm fragment size and doze of 0.3 g/l to operate for the purpose of treating the characterized discharge water of JSC Moskoks. The experiments are carried out by the method of “State All-Union Standard of Russia” SAUS No. 17219-71 named “Active coals. Method for determining the total volume of pores by water”. For these analyses, we are applying each activated carbon grains of a fraction of 0.5-1.0 mm at 20$^o$C and phase contact by mixing with an intensity corresponding to the Rem value equal to ~2500 RPM and characterization of the kinetics of treatment of discharge water is shown in fig 1.

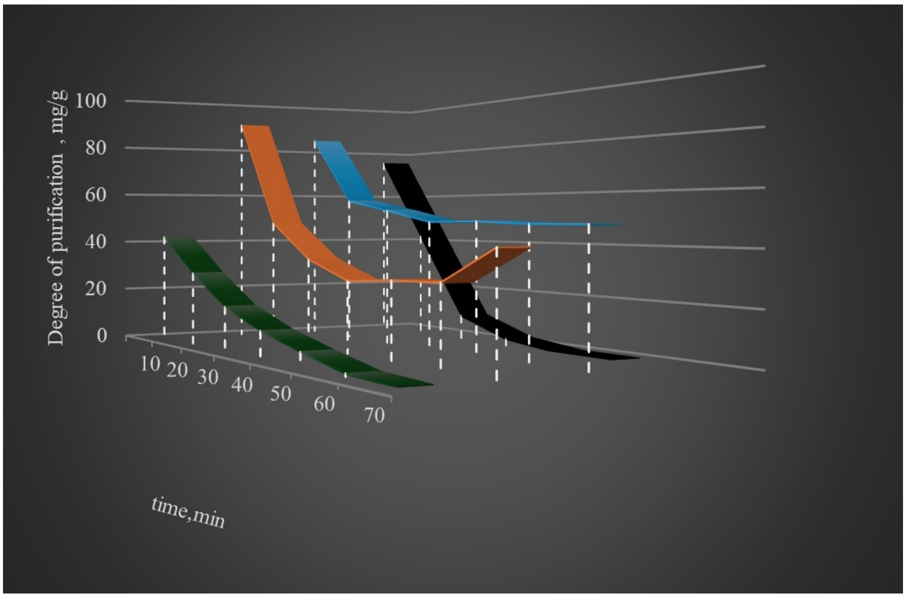


Figure 1 - Kinetics of wastewater treatment with obtaining activated carbons a dose of 0.3 g/l
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In figure 1, a green curve is represented for rice husk, orange curve for plum seed, light blue curve for iron wood and deep blue for tamarind seed shell. Absorption equations that formally describe kinetics for RH is $a=28\cdot exp^{-0,09}$, for PS : $a=21\cdot exp^{-0,06}$, for IW : $a=42\cdot exp^{-0,06}$, for TFS: : $a=10\cdot exp^{-0,06}$. In comparison of the data of these absorption values, we can determine that activated carbon TFS has the most active sorption degree than other comptitators. It can decrease organic impurities from given water body, which has 78 mg/l to 10 mg/l within 45 minutes of operational time.

**Conclusion**

Production of valuable carbon sorbent is expensive and challenging due to the technological problems from waste materials, especially for developing country such as Myanmar. Beyond these, annually, agricultural waste management is facing new problems for farmers. Therefore, the results of analyzing the real agri-waste from Myanmar are undoubtedly to produce activated carbon and advance usage of these obtaining carbon base sorbents which can eliminate the contamination of organic impurities from industrial discharge water and can compare with the other plant base activated carbon from global market. This fact can conclude that the experiments described above are not only benefic for reuse of non-valuable waste materials but also are including a part of solving of the environmental pollution problems.

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**Конфликт интересов**

Не указан.

**Conflict of Interest**

None declared.

**Рецензия**

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**Review**

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