International Journal of Modern Agriculture, Volume 9, No.3, 2020
ISSN: 2305-7246

INEXPENSIVE RESOURCES OF MYANMAR AS A SOURCE OF CARBON ADSORBENTS

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Abstract

The plant-based large-tonnage waste of numerous industries in Myanmar, in most of them, is not effectively used. The data of scientific and technical information indicate that on the basis of similar and similar in nature wastes, rather expensive products can be obtained in the form of carbon adsorbents of relatively high quality, intended mainly for solving the problems of deep purification of industrial effluents and emissions. No publications available on the feasibility and effectiveness of such a disposal of the named Myanmar wastes were found. The paper describes the results of experimental research by the authors, focused on solving this important problem of the national economy of the country.

Key words: vegetable waste; processing by steam-gas and chemical activation for active coals; production conditions, parameters of the porous structure and absorption properties of the obtained adsorbents

Introduction

The Republic of the Union of Myanmar is a country with a predominance of the agricultural sector in the economy, and its industrial sector is predominantly formed by mining enterprises. The cultivation, collection and processing of the crop of cultivated crops by organizations and units of various profiles accompanies the formation of large-tonnage waste, most of which do not find effective application, causing an ensemble of economic and environmental problems and requiring, in this regard, finding ways of their rational use in the interests of the national economy. A similar situation takes place at a number of enterprises related to the extraction of minerals, in particular, at the operated coal deposits.

At the same time, it should be emphasized that the activities of numerous enterprises operating in the country are associated with discharges and emissions that do not have proper deep cleaning, most often provided by the use of porous adsorbents in the form of activated carbons. The high cost of the latter on the world market and the practical absence of their own production facilities are included in the list of the main factors hindering the effective solution of the problems of protecting the biosphere.

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ISSN: 2305-7246

Literature review

Meanwhile, numerous publications of the second half of the last century and already the XXI century, in particular in the form of reviews [1, 2], indicate the fundamental possibility of obtaining carbon adsorbents of sufficiently high quality on the basis of waste mechanical wood processing, various agricultural production and food enterprises for solving the problems of cleaning emissions and discharges from pollutants of both organic [3-7] and inorganic nature [8-10] and a number of specific tasks in related industries [11, 12].

Our estimates, along with the data of available sources of information, lead to the conclusion that the annually renewable mass of waste from the cutting of stem wood, the volume of harvesting of which, including that of the Burmese iron tree (Railway), is about 6 million m3, and field remains of cotton cultivation on Myanmar plantations - Guza-Paya (GP) make up, respectively, about 10% of the harvested stem mass (~ 540 thousand tons) and 80% of the raw cotton crop (more than 450 thousand tons). The masses of waste from numerous food-processing enterprises and public catering units are also very impressive, where more than 5000 t / year of plum seed shells (PSS) are generated in the form of waste, approximately 6650 t/year mango seed shells (MSS), about 105 thousand t/year coconut shells (CS) and approximately 760 thousand tons per year of rice husks (RH), based on the typical rice crop in the country in recent years in the amount of 3.8 million tons per year.

The importance of the effective use of these wastes is emphasized by the basic principles of achieving national strategic goals, declared by the state forest policy of Myanmar, implemented in the country for the last 25 years, and including the efficient use of wood and wood products, the creation of wood processing industries that generate minimal waste, and the promotion of the use of less used wood species and value-added goods exports to foreign markets, adequate local production and supply to meet domestic needs, promoting finished timber exports to foreign markets, creating non-timber forest products and meeting local needs with new jobs.

According to the information available on the Internet about the raw material complexes of foreign countries, 16 deposits of fossil coal with total reserves of 258 million tons have been explored in Myanmar, of which the proven reserves amount to 4.62 million tons. Information about their potential as raw materials for the production of carbon adsorbents in the available sources of information was not found.

Available literature data indicate not only the efficiency of using some of these wastes, as such, for the purification of waste water from oil products, other organic impurities and heavy metal ions [13-16], but also the possibility of their processing to obtain sufficiently high-quality carbon adsorbents [17-22]. However, such information regarding the named waste generated in Myanmar is not found in the available publications. Along with this, it is known that raw material factors determine the quality of the obtained carbon adsorbents [23-25], which makes it expedient to experimentally evaluate the conditions for processing samples of the named national wastes and the quality of its target products.

Methodology

Such studies were carried out with the participation of the authors with the involvement of the most accessible for implementation in Myanmar conditions of waste pyrolysis with the subsequent activation of the resulting carbonizates with water vapor. For a number of these wastes, studies of various details were carried out in order to assess the feasibility and efficiency of their processing into carbon adsorbents using chemical activators. The activated carbons presented in the article were obtained from the above plant wastes: iron wood (Pyingado), mango seed shell, coconut shell, cotton tree and palm tree crushed to a size of 5-10 mm in an air-dry state. These materials weighing 20 g were subjected to pyrolysis in a steel tubular reactor, closed at one end, with the following parameters: heating rate 10° C / min, final temperature 750 °C for coconut shell (CS), 650 °C for iron wood (IW), 750 °C for cotton tree (CT), 600 °C for palm seed (PS) and 600°C for mango seed (MS). Isothermal time is maintained 60 min for CS and CT, 10 min for PS, 30 min for MS and 700 min for iron wood.

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ISSN: 2305-7246

Solid products of pyrolysis (carbonizates) after cooling were weighed, determining their yield through the ratio of the masses of carbonizate and raw materials.

Then carbonizates were activated in a steel tubular reactor with water vapor at a flow rate of 5-10 g / min at a temperature of final temperature 850 °C for coconut shell (CS), 850 °C for iron wood (IW), 800 °C for cotton tree (CT), 800 °C for palm seed (PS) and 700°C for mango seed (MS).° C. The yield of active carbons after cooling and weighing was found similar to the yield of carbonizates.

Alternatively, the waste was subjected to chemical activation: impregnated with Na_2CO_3, K_2CO_3, H_2SO_4, H_3PO_4, NaOH and $ZnCl_2$ solutions with a waste: activator mass ratio = 1:1 for each waste material, kept for 24 h, dried and heated as in pyrolysis. The resulting activates were washed 5-10 times with distilled water until the pH (or electrical conductivity) characteristic was reached and again dried to constant weight. Among the generally accepted instrumental techniques for sufficiently reliable determination of the parameters of the porous structure of adsorbents, the most widely used are those based on the study of the equilibrium of nitrogen absorption by them at 77 K [50]. This analysis was carried out on the equipment of the Center for Collective Use of the N.N. DI. Mendeleev: analyzer ASAP-2020 with processing of adsorption and desorption isotherms by various methods.

The quality of the obtained activated carbons was also evaluated according to standard indicators: activity for iodine and methylene blue dye. The first indicator is determined by a decrease in the concentration of 100 ml of 0.1 N. iodine solution with its continuous shaking with 1 g of adsorbent. The second indicator is the clarification of 25 ml of a 0.15% solution of the dye with its continuous shaking with 0.1 g of the adsorbent.

Research results

The properties of the raw materials used and the results of their thermographic tests are highlighted in the publications of a number of conferences ("Recycling, waste processing and clean technologies", M .: FSUE "Institute" Gintsvetmet ", 2014;" Advances in chemistry and chemical technology ", M: RCTU named after D. I. Mendeleev, 2015-2020; "Chemical technology of functional nanomaterials" M .: RCTU named after D. I. Mendeleev, 2017; "Actual problems of theory and practice of heterogeneous catalysts and adsorbents", Ivanovo-Pless, 2018; " Environmental safety in conditions of sustainable development ", Irkutsk: ISU, 2018;" Life safety: problems and solutions "Kurgan: Kurgan State Agricultural Academy, 2018;" Actual problems of theory and practice of heterogeneous catalysts and adsorbents "Ivanovo - Suzdal, 2019;" Environmental , industrial and energy safety "Sevastopol: SSU, 2017-2020; Ninth' International conference on Advances in Bio-Informatics, Bio-Technology and Environmental Engineering, Italy, Rome, 2019, specialized journals [26-29] and RF patents. The papers [26, 28, 29] also characterize the expedient conditions for the implementation of pyrolysis and activation operations, which determine a rational combination of the yield and absorption capacity of the obtained carbon adsorbents.

Among the generally accepted instrumental techniques for sufficiently reliable determination of the parameters of the porous structure of adsorbents, the most widely used are those based on the study of the equilibrium of nitrogen absorption by them at 77 K [25]. Such information about a number of carbon adsorbents obtained under the named rational conditions is reflected by comparative data in Table 1.

Table 1. Parameters of the porous structure of carbon adsorbents obtained from wood and stone waste

Indicators	Indicator value for carbonizate / active carbon:			
	Ironwood	Mango-seed	Coconut shell	Cotton tree
S_{BET}, m^2/g(BET)	345,8/737,2	450,16/577,66	411,50/785,92	429,29/480,61
t-Plot V_{min}, cm^3/g	0,119/0,145	0,136/0,212	0,154/0,246	0,159/0,159
t-Plot S_{min}, m^2/g (Micropor Area)	302,7/391,8	405,39/536,01	388,27/619,44	412,17/461,28

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ISSN: 2305-7246

t-Plot External Surface Area, m^2/g	43,1/345,4	44,77/42,65	23,22/166,48	21,38/19,33
BJH Adsorption cumulative volume of pores 1,7-300 nm, cm^3/g	0,010/0,188	0,0190/0,0205	0,012/0,072	0,013/0,014
BJH Desorption cumulative volume of pores 1,7-300 nm, cm^3/g	0,005/0,183	0,0185/0,0160	0,005/0,074	0,011/0,012
BJH Adsorption cumula-tive Surface Area of pores 1,7-300 nm, m^2/g	5,4/134,7	5,958/14,441	7,833/69,772	6,506/6,747
BJH Desorption cumula-tive Surface Area of pores 1,7-300 nm, m^2/g	1,29/161,15	4,6183/13,739	2,272/84,110	6,301/6,639
BJH A average D_{por}, nm	7,736/5,576	12,1439/5,7000	6,1095/4,1581	8,1264/8,1042
BJH D average D_{por}, nm	14,33/4,54	16,0233/4.6480	9,5660/3,5271	6,7053/7,2137
D/R S_{min}, m^2/g	338,9/800,2	428,45/626,18	472,40/846,66	475,68/463,5
Monolayer capacity, cm^3/g	77,8/183,8	98,42/143,84	108,52/194,49	109,27/106,47
D/A S_{min}, m^2/g	264,3/801,3	454,51/640,83	381,83/827,21	472,93/463,56
Density V_{min}, cm^3/g	0,109/0,310	0,160/0,236	0,157/0,313	0,177/0,167

Analysis and comparison of the data in Table 1 with those given in the above publications and works [30-34] for carbon adsorbents obtained from similar and related types of waste allow us to trace the evolution of porous structure parameters during the transition from carbonizates to activated carbons and to state the level correspondence of their values to the literature data.

The discussion of the results

As emphasized in [35], with close values of the compositional indicators, technical characteristics and processing conditions of raw materials in the form of waste of similar types, the yield and individual properties of carbon adsorbents obtained from the named Myanmar wastes do not always correspond to the best of those published in available sources of information. Nevertheless, with different and in some cases high efficiency with their use, it is possible to solve the problems of cleaning from organic impurities from industrial emissions and discharges [36, 37].

It should be emphasized that these carbon adsorbents, as noted in the proceedings of the above conferences, also demonstrate very high operational properties in solving a number of important applied problems.

One of the most important among them is water purification from phenols and its derivatives - an area in which about 1/3 of the world production of activated carbons is consumed [24, 38, 39]. Available publications indicate that the tasks of this circle are successfully solved by using carbon adsorbents obtained from various types of biomass [40, 41]. It is possible to solve such problems by attracting active carbons obtained by us from the shell of coconut nuts and plum seeds.

The study of applied areas of the use of carbon adsorbents obtained from waste revealed a high efficiency of the use of active carbons based on guza-pa for the adsorption of residues of the herbicide atrazine (mayazine) in the soil and those on the basis of crushed fragments of wooden furniture for binding simazine and its degradation products from water solutions. The problems associated with these herbicides, in particular with their entry into food and feed products, are especially relevant in the agricultural sector of Myanmar, as atrazine is one of the main herbicides used in rice cultivation and simazine is a selective systemic herbicide widely used in as a means of inhibiting the growth of grasses and broadleaf weeds. Their effective solution is usually associated with the use of rather expensive active carbons.

The combination of high absorption rates of iodine and methylene blue dye characterizes the ability of carbon adsorbents to simultaneously extract organic impurities with molecules of various sizes from aqueous solutions and is a constant subject of improvement [42]. Most of the activated carbons obtained from these Myanmar wastes are capable of efficient treatment of multicomponent industrial effluents, but the most effective among them in terms of providing the specified indicators are carbon-mineral adsorbents based on rice husks [43].

With relatively low rates of the depth of purification of industrial effluents of complex composition from organic pollutants and the capture of vapors of volatile organic solvents from their mixtures with air, activated carbon based on mango seed shells in the form of particles less than 100 microns in size provides a very high efficiency of clarification (purification) of injectable aqueous solutions medical gelatin 10%, produced in the pharmaceutical industry.

Activated carbon, obtained from the waste of mechanical processing of Burmese ironwood stem wood, provides deep purification of tobacco smoke from methanol, one of its most toxic components.

In contrast to steam-gas, chemical activation of materials of plant origin, similar to the above-mentioned Myanmar wastes, in a number of cases ensures the production of adsorbents of higher quality [44–47]. Experimental studies of this plan, carried out with the above-mentioned Myanmar wastes, found that the expediency of using chemical activation agents in the form of Na_2CO_3, K_2CO_3, H_2SO_4, H_3PO_4, NaOH and $ZnCl_2$ in relation to rice husks, coconut shells and plum seeds is excluded, at least in investigated its conditions. A noticeable consequence of chemical activation is the appearance of more or less pronounced cation exchange capacity in some of its target products, which may be practically important [48], but which is lacking in adsorbents obtained by pyrolysis of this raw material and activation of its carburized residues with water vapor. The results of chemical activation of guza-pays using $ZnCl_2$, NaOH, Na_2CO_3, K_2CO_3, H_2SO_4 and H_3PO_4 also indicate its low feasibility. The modification of active carbon obtained from ironwood wood by steam activation with thiourea and the subsequent pyrolysis of the impregnate cause a significant increase in the efficiency of wastewater treatment from organic impurities and a change in the ion-exchange properties of the target product in the form of a pronounced manifestation of the cation-exchange ability.

Certain prospects in terms of obtaining good quality active coals from the fossil coals of the Kaleiwa and Tijit deposits of Myanmar are their chemical activation with NaOH, an agent often used in studies of this orientation [49-51].

Conclusion

The stated results allow us to believe that the fundamental possibility of rational use of the characterized large-tonnage waste and fossil coals of the above-mentioned deposits of Myanmar deserves attention in order to obtain carbon adsorbents. The organization and implementation of their production in Myanmar will probably be able to ensure the competitiveness of these products and contribute to the effective solution with its use of the country's problems of protecting the environment from negative technogenic impact.

References

1. Muthanna J. Ahmed. Application of agricultural based activated carbons by microwave and conventional activations for basic dye adsorption // Journal of Environmental Chemical Engineering, Volume 4, issue 1, March 2016, pp. 89–99.

2. Muthanna J. Ahmed. Preparation of activated carbons from date (Phoenix dactylifera L.) palm stones and application for wastewater treatments // Process Safety and Environmental Protection, v. 102, July 2016, pp. 168–182.

3. Al-Wabel Mohammad I., Al-Omran Abdulrasoul, El-Naggar Ahmed H. et al. Pyrolysis temperature induced changes in characteristics and chemical composition of biochar produced from conocarpus wastes // Bioresource Technology, 2013, v. 131, pp. 374–379.

4. Metin Açıkyıldız, Ahmet Gürses, Semra Karaca. Preparation and characterization of activated carbon from plant wastes with chemical activation // Microporous and Mesoporous Materials, v. 198, November 2014, pp. 45–49.

5. AlOthman Zeid Abdullah, Habila Mohamed Abdelaty, Rahmat Ali et al. Valorization of two waste streams into activated carbon and studying its adsorption kinetics, equilibrium isotherms and thermodynamics for methylene blue removal // Arabian Journal of Chemistry, 2014, No 7, pp. 1148–1158.

6. Grigoriev L. N., Verentsova L. G., Shanova O. A. and others. Obtaining activated carbon from plant residues and evaluating its adsorption properties // KRS, 2015, no. 4, pp. 93-99.

7. Jechan Lee, Xiao Yang, Seong-Heon Cho et al. Pyrolysis process of agricultural waste using CO2 for waste management, energy recovery and biochar fabrication // Applied Energy, 2017, v. 185, pp. 214–222.

8. Mohammod M., Sen T.K., Maitra S. et al. Removal of Zn2+ from Aqueous Solution using castor Seed Hull // Water Air Soil Pollut., 2011, No. 215, pp. 609–620.

9. Ilyas Mohammad, Khan Nadir, Sultana Qamar. Thermodynamic and Kinetic Studies of Chromium (VI) Adsorption by Sawdust Activated Carbon // Journal Chemical Society of Pakistan, 2014, v. 36, pp. 1003–1012.

10. Mitrakova T. N., Lozinskaya E. F., Hoang K. B., etc. Use of sorbents from plant waste for wastewater treatment from copper (II) ions // Water: chemistry and ecology, 2015, no. 12, p. 56-63.

11. Veprikova E. V., Shchipko M. L., Chuparev E. N. Properties of powdered and tablet preparations based on enterosorbent from birch bark bast // HRS, 2010, no. 2, pp. 31-36.

12. Azizah Shaaban, Sian-Meng Se, Imran Mohd Ibrahim et al. Preparation of rubber wood sawdust-based activated carbon and its use as a filler of polyurethane matrix composites for microwave absorption // New Carbon Materials, 2015, v. 30, issue 2, pp. 167-175.

13. Zubakhin N.P., Klushin V.N., Dmitrieva D.A. et al. Removing Petroleum Products from Coke-Plant Wastewater by Means of Coal Cjncentrates and Coking Products // Coke and Chemistry, 2011 v. 54, No 4, pp. 129–132.

14. Kittiphoom S. Utilization of Mango seed // International food research journal, 2012, v. 19, pp. 325–335.

15. Yong Zhou, Lei Zhang, Zhengjun Cheng. Removal of organic pollutants from aqueous solution using agricultural wastes // Journal of Molecular Liquids, v. 212, December 2015, pp. 739–762.

16. Mamdouh S. Masoud, Wagdi M. El-Saraf, Ahmed M. Abdel – Halim et al. Rice husk and activated carbon for waste water treatment of El-Mex Bay, Alexandria Coast, Egypt // Arabian Journal of Chemistry, v. 9, Supplement 2, November 2016, pp. 1590–1596.

17. Sheveleva I. V., Holomeidik A. N., voit A.V. and others. Rice husk-based sorbents for removing Fe (III), Cu (II), Cd (II), Pb (II) ions from solutions // HRS, 2009, no. 4, pp. 171-176.

18. Hameed B.H., Ahmad A.L., Latiff K.N.A. Adsorption of basic dye (methylene blue) onto activated carbon prepared from rattan sawdust // Chemical Engineering Journal, 2011, v. 172, issue 1, pp. 326–334.

19. Akpen G.D., Nwaogazie I.L., Leton T.G. Optimum condition of color removal from waste water by mango seed shell based activated carbon // Indian Journal of Sience and Technology, 2011, v. 4, No. 8, p. 890–894.

20. Pandharipade S.L., Moharkar Yogesh, Thakur Raj. Synthesis of Adsorbents From Waste Materials Such As Ziziphus Jujube Seed & Mango Kernel // International Journal of Engineering Research and Applications (IJERA), 2012, v. 2, issue 4, pp. 1337–1341.

21. Zubakhin N.P., Klushin V.N., Starostin K.G. et al. Purification of Coke-Plant Waste by Carbon Adsorbents // Coke and Chemistry, 2015, v. 58, No. 2, p. 75–78.

22. Zenkova E. V., Klushin V. N., Zubakhin N. P. efficiency of carbon-adsorption treatment of effluents From the territory of coking production // Sorption and chromatographic processes (Sichp), 2017, vol. 17, no. 3, pp. 407-413.

23. Mukhin V. M., Tarasov A.V., Klushin V. N. Active coals of Russia. − M.: metallurgy, 2000. – 352 p.

24. Samonin V. V., Podvyaznikov B. L., Nikonova V. Yu., etc. Sorbing materials, products, devices and processes of controlled adsorption. Saint Petersburg: Nauka, 2009, 271 p.

25. Mukhin V. M., Klushin V. N. Production and application of carbon adsorbents. LAMBERT Academic Publishing. 2018. – 308 p.

26. Klushin V. N., Nistratov A.V., Saw Win Myint. Assessment of the quality of rice and coconut processing waste in the Republic of Myanmar as raw materials for the production of active coals // Chemical industry today (khps), 2016, no. 2, pp. 20-25.

27. Thu Aung si, Win Myint Saw, Klushin V. N. et al. Research of the porous structure of activated carbon from rice husks // Sichp, 2017, vol. 17, no. 1, pp. 916-923.

28. Naing Linn SOE, Zin Moe, Saw Win Myint, etc. Technological aspects and indicators of processing iron wood waste and mango seed shells for carbon adsorbents // khps, 2018, no. 4, pp. 28-34.

29. Naing Linn Soe, Zin Moe, Saw Win Myint, etc. Carbon adsorbents based on plant waste of Myanmar as a means of cleaning industrial emissions and discharges // Sichp, 2019, vol. 19, no. 5, pp. 574-581.

30. adeeva L. N., Odintsovo M. V. Sorbent for wastewater treatment from pine nut shells // Izvestiya Vuzov. Chemistry and chemical technology, 2009, vol. 52, issue 7, pp. 86-89.

31. Temirkhanov B. A., sultygova Z. Kh., Archakova R. D., etc. Synthesis of highly effective sorbents from walnut shells // Sichp, 2012, vol. 12, issue 6, pp. 1025-1032.

32. Saveleva Yu. R., Kryazhov A. N., Bogomolov M. S., etc. Obtaining activated carbon from the shell of a pine nut // HRS, 2003, No. 4, pp. 61-64.

33. Jechan Lee, Xiao Yang, Seong-Heon Cho et al. Pyrolysis process of agricultural waste using CO2 for waste management, energy recovery and biochar fabrication // Applied Energy, 2017, v. 185, pp. 214–222.

34. Deiana A.C., Sardella M.F., Silva H. et al. Use of grapestalk. A waste of viticulture industry, to obtain activated carbon // J. Hazardous Mater., 2009, v. 172, № 1, p. 13–19.

35. Saw Win Myint, Klushin V. N., si Thu Aug, etc. Evolution of the porous structure of coconut carbonizate during activation // Sichp, 2016, vol. 16, no. 5, pp. 280-284.

36. Naing Lin SOE, Zin MoE, Min Thu, etc. Carbon adsorbents based on plant waste of Myanmar as a means of cleaning industrial emissions and discharges // Sichp, 2019, vol. 19, no. 5, pp. 574-581.

37. Klushin V. N., Nistratov A.V., So Win Myint et al. Assessment of the quality of rice and coconut processing waste in the Republic of Myanmar as raw materials for the production of active coals // khps, 2016, No. 2, p. 20-25.

38. Zenkova E. V., Klushin V. N. Duration of contact of chipboard flour and sulfuric acid solution of polyurethane foam as a means of influencing the properties of granulated active coals // khps, 2016, issue 2, pp. 26-30.

39. Kinle H., Bader E. active coals and their industrial application / TRANS. from German, ed. by T. G. Plachenov and S. D. Kolosentsev L.: Chemistry, 1984. – 215 p.

40. Akpen G.D., Nwaogazie I.L., Leton T.G.. Adsorption characteristics of mango (Magnifera indica) seed shell activated carbon for removing phenol from wastewater // Journal of Applied Science and Technology, 2014, v. 19, No 1-2, pp. 43–48.

41. Zaharaddeen N. Garba, Afidah Abdul Rahim. Evaluation of optimal activated carbon from an agricultural waste for the removal of para-chlorophenol and 2,4-dichlorophenol // Process safety and environmental protection, v. 102. July 2016. pp. 45–63.

42. Kien Tiek Wong, Nguk Chin Eu, Shaliza Ibrahim et al. Recyclable magnetite-loaded palm shell-waste based activated carbon for the effective removal of methylene blue from aqueous solution // Journal of Cleaner Production, v. 115, March 2016, pp. 337–342.

43. Saw Win Myint, Naing Lin Soe, Zin MoE, etc. Thermal recycling of plant waste in Myanmar with the production of carbon adsorbents // Bashkir chemical journal, 2020, vol. 27, no. 1, pp. 61-67.

44. Feng-Chin Wu, Ru-Ling Tseng, Ruey-Shin Juang. Comparisons of porous and adsorption properties of carbons activated by steam and KOH // Journal of Colloid and Interface Science. Carbon, 2010, v. 48, issue 11, pp. 3157–3168.

45. Tsyganova S. I., Zhizhaev a.m., Bondarenko G. N. et al. Synthesis of porous metal-carbon materials based on birch wood modified with zinc chloride and ferrocene // HRS, 2015, no. 3, pp. 205-211.

46. Kundu A., Gupta B.S., Hashim M.A. et al. Taguchi optimization approach for production of activated carbon from phosphoric acid impregnated palm kernel shell by microwave heating // Journal of Cleaner Production, 2015, v. 105, No. 15, pp. 420–427.

47. Hasan Sayğılı, Fuat Güzel. High surface area mesoporous activated carbon from tomato processing solid waste by zinc chloride activation: process optimization, characterization and dyes adsorption // Journal of Cleaner Production, v. 113, February 2016, pp. 995–1004.

48. Nour T. Abdel-Ghani, Ghadir A. El-Chaghaby, Mohamed H. El-Gammal et al. Optimizing the preparation conditions of activated carbons from olive cake using KOH activation // New Carbon Materials, v. 31, issue 5, October 2016, pp. 492–500.

49. Sahu J.N., Acharya Jyotikusum, Sahoo B.K. et al. Optimization of lead (II) sorption potential using developed activated carbon from tamarind wood with chemical activation by zinc chloride // Desalination and Water Treatment, 2016, v. 57, pp. 2006–2017.

50. Lillo-Rodenas M.A., Cazorla-Amoros D., Linares-Solano A. Understanding chemical reactions between carbons and NaOH and KOH. An insight into the chemical activation mechanism // Carbon, 2003, v. 41, No 2, pp. 267‒275.

International Journal of Modern Agriculture, Volume 9, No.3, 2020
ISSN: 2305-7246

51. Raymundo-Pinero E., Azais P., Cacciaguerra T. et al. KOH and NaOH activation mechanisms of multiwalled carbon nanotubes with different structural organization // Carbon, 2005, v. 43, No 4, pp. 786–795.