International Journal of Industrial Engineering & Production Research March 2020 Vol. 31, No. 1: 51- 61
DOI: 10.22068/ijiepr.31.1.51

RESEARCH PAPER

Pretreatment Process Selection in A Biofuel Production Line

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Received 3 January 2020; Revised 25 January 2020; Accepted 28 January 2020; Published online 31 March 2020

ABSTRACT
Regarding population growth and prompt development in developing countries, municipal solid waste management is always a great challenge for governments. Waste to energy conversion is an efficient approach with respect to overcoming not only the challenge of municipal solid waste management but also environmental challenges related to energy consumption such as global warming and fossil fuel depletion. One of the substantial problems throughout the implementation of waste to energy approach is process selection. The selected process should be technically feasible and should have a high level of compliance with environmental standards. Owing to the inevitable significance of process selection, this paper focuses on defining the best process by relying on multi-criteria decision-making tools and network analytic process. Considering the effective parameters such as cost, efficiency in material diversity, productivity rate, energy consumption, pollutant emissions, toxic substances, and process time, the result indicates that the physico-chemical process is a superior process for the pretreatment of material.

KEYWORDS: *Biofuel; Pretreatment; Multi-criteria decision making; Analytic network process; Municipal solid waste.*

1. Introduction

Urban waste daily production is rising rapidly due to increased urbanization, rapid population growth, and rising food consumption. Today, other traditional waste collection and disposal systems are not responsive and cannot prevent environmental pollution from chemical, microbial, and radioactive waste. The adoption of waste management law can be one of the most important steps in improving the status of solid waste management. In practice, waste recycling is an appropriate, sustainable and necessary process in the global economic chain. It requires a waste management process aimed at reducing the utilization of edible raw materials and excessive use of waste incineration and disposal [1].

Municipal Solid Waste (MSW) involves (a) household waste plus commercial waste that the council manages recycling, (b) gardens waste, (c) non-household clinical waste cleared fly tips, and (d) a number of other minor categories of waste managed by the council. MSW contains a wide range of materials. It can be classified into three broad categories: dry recyclables, biodegradable municipal solid waste (BMSW), and residual waste.

Inert matter, typically glass and metals, and stable organic matter can be categorized into dry recyclables. Biodegradable organic matter such as kitchen waste, food residues, paper cardboard, grass cuttings, and tree clippings and other garden wastes belong to Biodegradable Municipal solid waste class. Finally, residual waste typically consists of stones, sand, composite, and contaminated materials [2].

Moreover, bioethanol is a liquid biofuel produced from several different raw materials using different conversion technologies. Bioethanol is an attractive alternative fuel because it reduces the amount of suspended particulate matter and nitrogen oxides produced by the engines.

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Ethanol is the most important solvent after water. The main commercial uses of ethanol represent a solvent in the manufacturing of cosmetics, detergents, disinfectants, medicines, and foodstuffs. The application of ethanol to disinfect surfaces used in operating rooms and hospitals, clinics and isolated rooms, and public places for hand disinfection and disease prevention (including contagious infections) are essential in all public outlets, offices, shops, stadiums. In addition, it is used in disinfecting and sterilizing contaminated food production lines.

Ethanol is used as a raw material in the synthesis of ethanol chemicals for manufacturing various materials such as acetaldehyde, butadiene, diethyl ether, ethyl acetate, ethylene, glycol ether, vinegar, and so on. In some countries like Brazil, many chemicals are produced from ethanol. The most important role of ethanol as the largest chemical solvent in the synthesis and production of medical drugs is the mainstay of many drugs in processing and production. An important part of veterinary medicines is also produced using ethanol in the production process.

In recent years, in response to controlling and reducing carbon dioxide emissions, bioethanol has become one of the most promising biofuels. For example, the European Union's commitment to upgrading biofuels for transport by 2010 was 5.75% of total transport fuel and increased to 10% by 2020.

In addition to the applications mentioned above, bioethanol can be used as a substitute for methyl tertiary butyl ether (MTBE), which is now widely substituted for lead compounds in automotive gasoline. The task of MTBE is to increase gasoline octane. Ethanol fuel provides a part of octane boost for car fuel, too. The high-octane number of ethanol causes complete combustion and reduces the emission of environmental pollutants. Bioethanol is not toxic like lead and MTBE and, because of its solubility, causes the saturation of gasoline impurities in the filter. Its antifreeze property prevents fuel freezing in cold weather even in winter.

The main focus of this work is BMSW because it contains a significant amount of organic matter, especially carbohydrates for subsequent use in bioethanol fermentation. In addition, the application of urban waste in the production of biofuels is, in fact, an intact resource and helps control the challenges of waste disposal, too. Since the composition of the waste is heterogeneous and forms a major part of the lignocellulosic material, it needs pretreatment processes to remove barriers to its exploitation.

1.1. Effective parameters in municipal pretreatment

A large content of waste is formed by lignocellulosic material. Lignocellulose is resistant to enzymatic attack due to cellulose, hemicellulose, and lignin. The pretreatment process provides necessary conditions for enzymatic disintegration [3,4].

Crystallinity: Enzymes are not effective in destruction crystalline fractions, and the degradation of crystallite enhances the digestion of lignocellulose. The results indicate that crystallite is an important factor in the digestion of lignocellulose [3].

Effect of accessible surface area: To remove lignin and hemicellulose off the accessible surface of cellulose, enzyme hydrolysis improvement is necessary. The effect of this area may be related to crystallite, lignin, hemicellulose, and or all of them. The presence of water on the cellulose accessible surface is very important. The accessible surface increases with soaking [3,5].

Effect of lignin: Cellulose and hemicellulose bond by lignin. Lignin is a factor in the consolidation of the structure, impregnability, and resistance to microbial attack. Therefore, the efficiency of enzymatic hydrolysis can be improved by lignification processes [5].

Effect of hemicellulose: Hemicellulose surrounds cellulose fibers and can protect cellulose from enzymatic attack. It has been shown that many of the pretreatment techniques are capable of removing hemicellulose and, thus, improving enzymatic hydrolysis [3,5].

1.2. Pretreatment methods

Pretreatment is one of the costliest processes for the production of cellulosic ethanol that includes 33% of total processing costs, according to Renewable Energy Laboratory [2]. Therefore, it is necessary to select an appropriate pretreatment method. The main pretreatment methods including physical, chemical, physico-chemical, and biological are briefly described in this section.

1.2.1. Physical method

Physical pretreatment can increase the accessible surface area and size of pores. It decreases the crystallinity and degrees of polymerization of cellulose. The most important processes of this group are milling, extrusion, irradiation, and pyrolysis.

- Milling: Reduction of particle size can be done by chipping, milling, or grinding. Mechanical pretreatment is typically combined with other methods, and the desired particle size depends on subsequent steps. It can help material handling easier. However, it is a high energy consumption process that makes it generally not economically feasible [3,6].

- Extrusion: In this process, materials are treated at a temperature higher than 300°C. In this process, mixing and shearing results in physical and chemical modifications of cellulose. The screw speed and barrel temperature in the extrusion process can disrupt the lignocellulosic structure [5].
- Irradiation: Enzymatic hydrolysis of lignocelluloses can be improved through irradiation, electron beam, microwaves, and combination of the radiation and other methods such as acid treatment. Irradiation enhances the enzymatic degradation of cellulose into glucose [3,7].
- Pyrolysis: this method is used for the pretreatment of lignocellulosic materials. Cellulose rapidly decomposes into gaseous products and residual char when biomass is treated at temperatures greater than 300 °C. The decomposition is much slower, and the products formed are less volatile at lower temperatures [4].

1.2.2. Chemical method

The pretreatments that are purely initiated by chemical reactions to disrupt the biomass structure is categorized in the chemical method. Acid hydrolysis, Alkali, Ionic liquids, Ozonolysis, Organosolv, and Oxidation are combinations of chemical pretreatment that is dealt with in the following.

- Acid: The acid hydrolysis can efficiently improve the enzymatic hydrolysis. The acid pretreatment can operate at different temperatures and acid concentration level. Concentrated acid can be performed at a low temperature that saves costs, but it is corrosive and requires the recovery of acid, which is a costly process. The diluted acid can be used at high temperatures, which damages the structure of sugar [3,4,6].
- Alkali: This process can efficiently increase the accessibility of enzyme to the cellulose. This process is performed at low temperatures. However, the high concentration of the base is requested in a relatively long time. Disadvantages of this method include long operating time, high energy consumption, and the need for neutralization after the pretreatment [4,5].
- Ionic liquids: This pretreatment process uses Ionic liquids (ILs) and temperatures ranging from 100 to 150C. In this process, anti-solvents are used to regenerate soluble biomass and, then, enzymatic hydrolysis produces fermentable sugars. It is a potent process for pretreating lignocellulosic biomass that can achieve more than 90% cellulose digestibility [4].
- Ozonolysis: In this pretreatment method, lignocellulosic materials are performed by treatment with ozone that can effectively degrade lignin and part of hemicellulose. Moisture content of the sample, particle size, and ozone concentration in the gas flow can be listed as the main parameters of the Ozonolysis pretreatment process. However, it might be expensive since a large amount of ozone is consumed [3].
- Organosolv: in this process, the removal of lignin is performed by an organic solvent or mixtures of organic solvents with water before enzymatic hydrolysis of the cellulose fraction. It can improve the enzymatic digestibility of the cellulose fraction. However, this is a costly process. Since organic solvents are inflammable, their uncontrolled use may cause danger [3,6].
- Oxidation: Delignification of lignocellulose can also be achieved by treatment with an oxidizing agent. The effectiveness in delignification can be attributed to the high reactivity of oxidizing chemicals with the aromatic ring. Thus, lignin polymer is converted into inhibitor compounds, and they must be neutralized or removed. This process requires a high temperature and pressure [5,6].

1.2.3. Physico-chemical method

Physico-chemical processes combine both chemical and physical processes. The most important processes of this group will be dealt with in the following.

- Steam explosion: this process is one of the most applied pretreatment processes because of its low use of chemicals and limited energy consumption. In this method, high-pressure saturated steam is injected into a batch or continuous reactor filled with a biomass. However, this process could affect the enzymatic hydrolysis and fermentation process [4].
- Ammonia fiber expansion: in this process, biomass is treated with liquid ammonia at a high temperature and pressure, and the pressure is swiftly reduced. It reduces the lignin content and removes some hemicellulose while decrystallizing cellulose. The main advantage of the ammonia pretreatment is the low cost of ammonia. Another advantage is that it does not

produce inhibitors for the downstream biological processes [4,6].

- Steam explosion with carbon dioxide: in this process, yields of CO_2 explosion are lower than those obtained with both of the mentioned processes. However, they are higher than those reached with enzymatic hydrolysis without pretreatment [6].
- Liquid hot water: it is one of the hydrothermal pretreatment methods applied for pretreating lignocellulosic materials. In this method, temperature and time change the amount of sugar produced [5].

1.2.4. Biological method

In the biomedical processes, bacteria and microorganisms such as brown fungi, white fungi, and soft fungi are used to destroy lignin and hemicelluloses in waste. Applied microorganisms usually break down lignin and hemicellulose and have little effect on cellulose because they are more resistant to biological attack than other parts of lignocelluloses. A suitable fungus in biochemistry must have a lignin-like structure and decompose lignin sooner than carbohydrates.

Brown fungi predominantly attack cellulose and have a slight effect on lignin, while white and soft fungi attack both cellulose and lignin. White fungus as the most promising species in bioethics is much researched. Biosciences are characterized by no chemicals, low energy consumption, mild environmental conditions, and no negative impact on the environment. However, biological processes are slow and require a careful control of the growth conditions of microorganisms and the large space for treatment. Most lignin-solubilizing microorganisms also solubilize or destroy hemicelluloses, and the effectiveness of this technique is challenged [3,5,6].

2. Literature Review

Over the past decades, energy planning approaches have become a complex system due to conflicting criteria and goals. The current energy planning has several goals, definitions, and criteria that make it difficult to achieve a sustainable system. To solve such complex problems in energy planning, multi-criteria decision-making (MCDM) is one of the most efficient methods. The techniques presented in MCDM can be used to find a suitable solution to energy system design problems that involve multiple and conflicting goals [8].

Beltran et al. (2010) presented the Analytic Network Process (ANP) to select the best location of a municipal solid waste plant in the Valencia. Choosing the right location of the facility can be considered as a complex multi-criteria decision-making problem because it requires an extensive evaluation of the potential locations of the municipal solid waste plant and other diverse factors such as economic, technical, legal, social, or environmental issues. According to their study, ANP is a useful and reliable tool for facilitating professionals in decision-making [9].

Moreover, Beltran et al. (2014) applied AHP and ANP to assist the board of directors of a major Spanish solar power company. In the first two stages of decision-making, the board decides whether to accept or reject a project. Next, the priority of economic projects is determined by the level of risk and time delay [10].

Jaafari et al. (2014) applied the network analysis process for sustainable forest management. According to the four criteria of benefits, opportunities, costs, and risks and four wood extraction options, they selected one based on the sustainable forest management strategy obtained using existing information or a questionnaire completed by forestry engineering experts. The decision framework presented in this study provides a means to reorganize and plan wood harvesting operations as an integral step towards SFM. Given the local circumstances, this decision-making framework can be applied to many other regions and countries [11].

Molinos Senante et al. (2015) utilized the ANP to deal with the challenges and complexity of selecting the most appropriate wastewater treatment technology. Their study performed sensitivity analysis that showed a stable ranking of wastewater treatment alternatives [12]. The effectiveness of project selection in the case of social network analysis was studied by Grady et al. (2015). The research results enable companies, government agencies, and other organizations to prioritize strategic network goals at the same time as research and development priorities [13].

Boateng et al. (2015) employed the ANP methodology to improve Megaprojects, which often face social, technical, economic, environmental, and political challenges for project management and are expensive projects. There are many risks involved in planning and funding these projects. Although some risk planning and scheduling considerations are taken into account, the challenge of modeling the interactions and risk impacts on project performance remains the same. To address this technical problem, the study combined a new risk priority list based on the data collected from the Edinburgh Tram Network project at the construction stage [14].

Chemweno et al. (2015) applied the ANP to select a risk assessment technique in the field of maintenance. Different criteria affect the selection process, and these criteria vary according to organizational competencies in one company. In this method, selection criteria for Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), and Bayesian Networks (BN) were obtained based on the risk assessment process in ISO 31000: 2009. The criteria were prioritized using the ANP, taking into account the judgments and opinions of experts in the field of science and industry. The results showed that the proposed method was helpful in assisting maintenance practitioners with identifying the important competencies related to the particular technique and, thus, selecting the technique most appropriate for the organization [15].

Further, the application of biomass energy source network analysis process for electricity generation in Iran was evaluated by Safari et al. (2016). Four major available biomass energy sources available in Iran were considered in their research. At first, sources were compared based on different criteria and sub-criteria derived from the literature and specialized perspectives to select the most appropriate biomass source for fuel production needed for power plants. The results showed that the criterion of "economic and legal factors" was the most important among other criteria in evaluating biomass resources. In addition, biodegradable municipal waste is recognized as the most favorable source of biomass energy for power generation in Iranian power plants [16].

Vucijak et al. (2016) studied an efficient solid waste management strategy. This process has conflicting goals with a number of different solid waste management scenarios. Decisions should be made based on technical, economic, social, and environmental goals. The results of this paper demonstrate the reliability of using multi-criteria decision-making tools for the purpose of selecting the best municipal solid waste management scenario among six different options [17].

A multi-criteria decision-making model is designed to determine the impact of each element on efficiency and cost by Ebrahimi et al. (2017). They developed a multilevel network and applied the ANP. The two main criteria include system productivity model and initial cost of production. The productivity criterion has 7 sub-criteria, each of which has sub-criteria. The importance of cost to productivity depends on the demand of the decision-maker; therefore, it is assumed that their importance is equal. All other network information is collected from relevant scientific sources. The model illustrates a suitable screening tool across different photovoltaic systems [18].

Mahmoudkelaye et al. (2018) presented a model for selecting the best sustainable materials in the construction industry. Through sustainable principles, the selection criteria are divided into four groups that are identified as economic, technical, socio-cultural, and environmental factors. Each of them was then assigned a number of sub-criteria. The network analysis process was used as a multi-criteria decision-making method. The questionnaires were completed in line with expert agreement. The results revealed that aluminum siding was the best sustainable alternative, while cedar siding represented itself as the least sustainable option for construction building [19].

A multi-criteria decision-making was used to select shipping registry by ship-owners by Chou (2018). The network analytical process approach was used to find the factors that influenced the decision-making of the case file selection. In their study, the taxation of shipping, finance conditions, trade restrictions and barriers, crew costs, and incentives were the five most important sub-criteria. After constructing the hierarchy, the ANP model was applied to the Taiwan Transportation Registry, and the results showed that operating costs represented the most important factor followed by market conditions, national policies, and international laws and restrictions [20].

Alilou et al. (2019) presented an integrated method for determining the most appropriate sampling points in the Khoy watershed of Iran. To identify the exact locations of sampling points, a fuzzy ANP was used considering the economic resources and water quality data limit. Based on the case limitations, 15 candidate points were selected for sampling and weighting 12 criteria and 10 sub-criteria. The model results present a new total potential pollution score of candidate points. It was then classified and fuzzified to distinguish the real differences between scores. Finally, six points were suggested as the most suitable sites for surface water quality monitoring [21].

In this study, firstly, the effective parameters in the lignocellulosic pretreatment such as crystallinity, accessible surface, protection by lignin, and hemicellulose are investigated. Next, pretreatment methods including physical, chemical, physico-chemical, and biological are described. According to the effect of criteria in the system, the appropriate process is selected by using the network analysis process.

3. Method

3.1. Analytic network process technique

The analytical hierarchy process (AHP) and the ANP are two well-known methods proposed by Saaty. Both of them create hierarchical relationships between levels. The lower levels are the criteria and sub-criteria that help the target. The options whose evaluation is based on criteria will be placed at the lowest level. To assign a weight to the elements of each level, AHP utilizes the pairwise comparisons. The consistency rate (CR) verifies the consistency of the judgment, which should be about 0.9 or more. AHP is a concept that is easy to use; however, its hierarchical structure cannot solve many of the complexities of real-world problems. The ANP model was suggested as the extension of the AHP method. The ANP divided decision-making into groups as a network of criteria and options. The network can include any possible connection or complex feedback and communication within and between clusters. This method provides a more accurate model of the complex situation. The ANP structure is not a linear one. A super-matrix shows the effect of options and criteria [22]. Accordingly, the problem structure can be formulated, as given in Fig. 1.

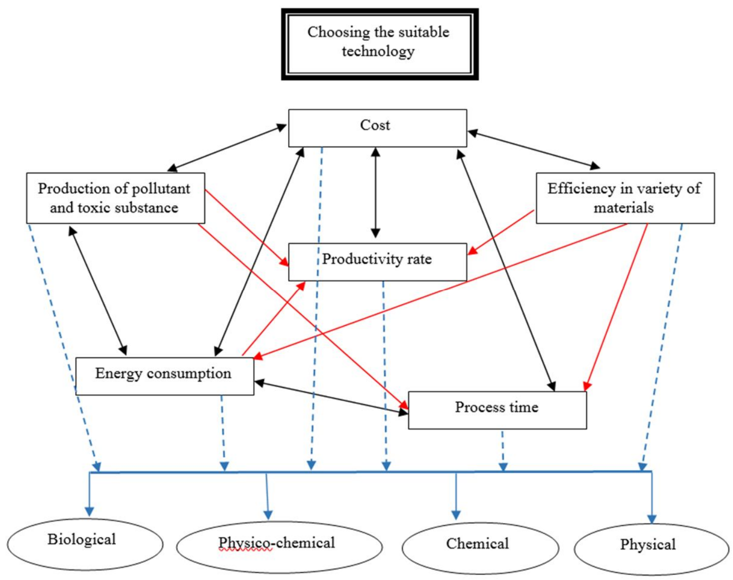

Fig. 1. Formation of the problem structure

3.2. ANP steps

ccording to Saatys, the ANP model includes the following steps:

Step1: By determining the problem structure, the problem must be expressed in a transparent manner and broken down into a logical system of a network.

Step2: Pairwise comparisons and priority vectors: to determine the relative weights of the main and sub-factors and their interdependencies, a pairwise comparison will be performed. The method of applying these pairwise comparisons is the same as what is used through 1–9 scale of Saaty. Then, one needs to obtain the local priority vectors for each pairwise comparison matrix. Thus, the eigenvector method is employed.

Step3: Determining the inconsistency rate; to obtain the overall prioritization in a system with dependent effects, local priority vectors are inserted into the appropriate columns of a matrix. The consistency ratio (CR) is presented to test the consistency of a pairwise comparison. The pairwise comparison will be acceptable if the CR is less than 0.1. Otherwise, the comparisons need to be repeated.

Step4: Super matrix formation; the ANP model is based on a comparative judgment of the alternatives and criteria. If the super-matrix covers the whole network, the weight of the different clustering options and elements can be found in the corresponding columns in the super-matrix. After creating the local priority matrix for the criteria, a super-matrix is formed as given in Eq. (1).

$$W = \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & 0 \end{bmatrix} \quad (1)$$

Step 5: Calculating the final weight vector; after determining the local weights using the eigenvector value, the global weights are calculated by raising the supermatrix to limiting powers as in Eq. (2).

$$W = \underset{k \to \infty}{Limit} \; W^{2k+1} \quad (2)$$

3.3. Explaining the criteria

The main criteria for selecting a process are costs, efficiency in material diversity, energy consumption, productivity rate, pollutant production, and process time, which are described in this section.

Costs: The cost criterion depends on many factors including the establishment, the purchase of materials and devices, the cost of operations, the process of retrieval and separation of additive compounds, or the destruction and erosion of equipment. According to the mentioned factors, the options are compared with cost criterion. There is a two-way internal relationship between cost and other criteria.

Efficiency in material diversity: it is easy to choose a technology for raw materials with the same biochemical combination and the same genus. However, according to the complex composition of urban and industrial wastes that consist of various materials and mixtures with different percentages, it is important that selected technology enjoy the necessary efficiency in this variety of materials. There is an internal relationship between this criterion and the cost, energy consumption, productivity rate, and process time. The cost affects all of them.

Productivity rate: the final product yield is compared with the type of material and existing methods, and a technology with acceptable productivity yield will be chosen. This criterion affects cost, energy consumption, and efficiency rates.

Process time: The time of the pre-treatment process affects the cost and amount of energy consumption. Therefore, time is considered as a criterion in the selection of suitable technology.

Energy consumption: The amount of energy consumed by different technologies is different. The energy consumed affects the process costs and productivity rate; therefore, energy consumption is also considered as an effective criterion in technologies' comparison. The energy consumption impacts the following criteria: cost, pollutant production, productivity rate, and process time.

Production of pollutants and toxic substances: in this study, due to the importance of environmental goals, technologies are compared with amount of pollutant release and toxic products. Therefore, pollutant production and toxic substances are considered as an effective criterion for the decision-making process. There is a relationship between this criterion and cost, energy consumption, efficiency rate, and process time.

4. Analysis of Results

In this paper, Super Decision software is used to establish the model and make the ANP calculations. The results of the paired comparison questionnaire completed by the experts are acquired. The structure is shown in Fig. 2. By adding the information to the Super Decisions, the weighted super matrix is formed by the program and is shown in Table 1.

Tab. 1. Weighted super matrix

		Alternatives				Criteria						Goal
Cluster node labels		Biological	Chemical	Physical	Physicochemical	Cost	Efficiency	Energy	Pollutant	Productivity rate	Process time	Find a suitable technology
Alternatives	Biological	0	0	0	0	0.0180	0.2143	0.2035	0.1817	0.2222	0.2474	0

	Chemical	0	0	0	0	0.1156	0.0634	0.1526	0.0339	0.0658	0.0666	0
	Physical	0	0	0	0	0.0904	0.0325	0.0444	0.1245	0.0203	0.0213	0
	Physicochemical	0	0	0	0	0.2758	0.1897	0.0994	0.1597	0.1915	0.1645	0
	Cost	0	0	0	0	0	0.5000	0.0311	0.1666	0.0432	0.0433	0.3928
	Efficiency in variety	0	0	0	0	0.0211	0	0.1280	0	0.0900	0.3046	0.1224
Criteria	Energy consumption	0	0	0	0	0.1213	0	0	0.3333	0.1285	0.1108	0.0260
	Pollutant production	0	0	0	0	0.0412	0	0.0342	0	0.1701	0.1108	0.0881
	Productivity rate	0	0	0	0	0.2496	0	0.3066	0	0.0680	0	0.0307
	Time	0	0	0	0	0.0666	0	0	0	0	0	
Goal	Find a suitable technology	0	0	0	0	0	0	0	0	0	0	0

According to Table 1, weighted super matrix, the criteria are prioritized in terms of cost, efficiency in the variety of materials, pollutant and toxic materials production, productivity rate, process time, and ultimately energy consumption. Considering the internal relations of the criteria, the prioritization of alternatives per criterion is given as follows:

1. The cost comparison of alternatives shows that they can be ranked as physico-chemical, chemical, physical, and biological. A remarkable difference betwen the alternatives in terms of the cost criterion is visible.
2. The priority of the options over the efficiency criterion in the variety of materials is biological, physico-chemical, chemical, and physical. Here, biological and physico-chemical options are the most efficient ones.
3. The priority of alternatives over energy consumption is biological, chemical, physico-chemical, and physical in order. In this criterion, the physical approach is ranked the lowest.
4. It can be stated that the alternatives can be ordered in the form of biological, physico-chemical, physical, and chemical in terms of the pollutant production and toxic substances measure. The biological and physico-chemical approaches are the best ranks in this comparison.
5. The priority of alternatives over productivity rates is biological, chemical, physico-chemical, chemical, and physical, respectively. Again, the biological and physico-chemical approaches are far better than other options.
6. The process time required for each of the approaches is analyzed, and the priority of options is in order of biological, physico-chemical, chemical, and physical process times. The trend of better performance is

again shown by biological and physico-chemical approaches.
Finally, the results show that the physico-chemical process is superior within the other three alternatives. The performance of the biological approach is the second best within the options. The order of the suitability of methods is shown in Figure 3.

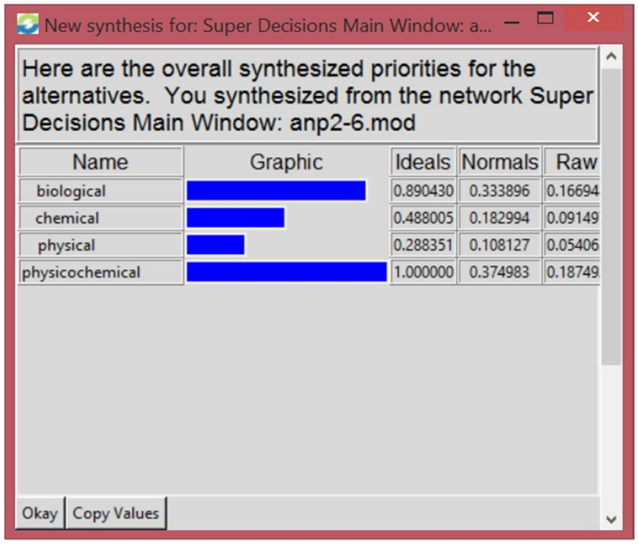

Fig. 3. The alternatives ranking

5. Conclusion

The issue of fuel production from the municipal solid waste caused a complete separation of the recyclable components of waste and the prevention of voidance and wastage. In addition, it produced a value-added product that prevents the pollution caused by traditional disposal methods. Moreover, it can change the request for using the forest land as farmland and using food sources that impede food security, and it is consistent with the low emission of greenhouse gases.
One of the main steps in this process is the pretreatment process. The pretreatment process seeks to break down the lignin structure and disrupt the crystalline structure of cellulose. It can be the most expensive process in biomass-to-fuels conversion; however, there is great potential for improvements in efficiency and cost reduction through further research and development. Since the economic and process efficiency are very influential in decision-making, this study applied a network analysis process approach to determine the pre-treatment process that has a great impact on cost and productivity. According to the results, the physico-chemical process is selected for the material pretreatment.

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