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An AHP for Prioritizing and Selecting Industrial Waste Management Method Case Study: Map Ta Phut Industrial Estate

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Abstract. The objective of this paper is to present an evaluation method that can aid decision to prioritize and select industrial waste management method. An Analytic Hierarchy Process (AHP) decision structure approaches to measure the relative desirability of disposal alternatives using value judgments as the input of the various stakeholders. The novel of this paper is a flexible analytical program that enables decision makers to find the best possible industrial waste management solution to complex problems by breaking down a problem into a systematic hierarchy structure among the various levels and attributes. The process of the evaluation method has been started from analyzing various factors which are used for designs the decision making structure.It is included with necessary data for consideration of management alternatives design that comprised of the technology, economics, environment, and also related regulations. The benefits of this method therefore may not only aid in selecting the best alternative but also help decision makers to understand why an alternative is preferred over the other options. A case study in Industrial Estate Authority of Thailand (IEAT), recommendations, limitations, and further research are also presented.

Introduction

Eco Industrial Town is a sustainable industrial development based on balance of economics, society, environment, consistency with law, and technological possibility. The Industrial Estate Authority of Thailand (IEAT) has applied this concept to specify a vision on being an Eco Industrial Town with qualifications and criteria of being an Eco Industrial Town in 5 dimensions, 22 aspects, and continuously processed a project on upgrading town to be an Eco Industrial Town. During the recent project management, it was found that an industrial waste management is an important issue particularly in Map Ta Phut area which is significant environmental impact for being upgraded to an Eco Industrial Town i.e. elimination of useful waste, and incorrect waste elimination. Thus, it is important to develop a supporting procedure to ensure an efficient decision making especially on properly selecting industrial waste management method. Justification is that there are many factors involving in the industrial waste management i.e. industrial group difference, number of factory, waste quantity, waste type, surrounding society, environment, stakeholder groups, etc. Thus, it must be done carefully in making decision on selecting each management method and all concerning factors must be considered altogether in terms of quantity and quality, technological possibility, economic worth, effect on environment, and limitations on law [1]. In this research, decision making waste management process by applied AHP is the performed. The AHP is a multi-criteria decision making method or an analytical decision making developed by Thomas Saaty. This is an effective method to prioritize significance and enable an authority to be able to select the best method [2, 3]. AHP's decision making process focuses on solving problem and is designed to have the decision maker prioritize complicated problems in hierarchy from objective, criteria, and alternative. Also AHP is a tool to help appropriate decision making for problem structure having quantitative variable i.e. analysis together with economic calculation's result from return on

investment (ROI), calculation with net present value (NPV) [4], and qualitative variable i.e. evaluating appropriate level of personnel, rules and regulations of waste management, energy or industrial logistic problem [5]. Moreover, the benefit of applied AHP in decision making method can be found in many research such as Feo and Gisi [6] etc.

Thus, this research's objective is to develop a procedure on prioritizing and selecting industrial waste management method by applying AHP to enable a proper selection of waste management method covering both quality and quantity aspects, and able to specify significance level of main and minor criteria that affect each hierarchy of decision making. The test will be on study case at Map Ta Phut Industrial Estate (MTPIE), where is the biggest petroleum and petrochemical industrial estate of Thailand. MTPIE applied the concept of industrial waste management method by product exchange and eco-efficiency into the actions [7] with the objectives of improving environmental performances and industrial competitiveness toward to the goal of sustainable development being Eco Industrial Town in the future.

Methodology

The research procedure consists of 2 parts which are sorting out data to be used for decision making, and making decision using AHP by stakeholders in the study case's area. The decision making in the second part is to decrease bias of the stakeholders in the area. The research, then, divides total score (100%) on decision making into 2 parts. The first 50% score is from the stakeholders in the area and the other 50% score is from external specialist. The research procedure is as shown in Fig. 1.

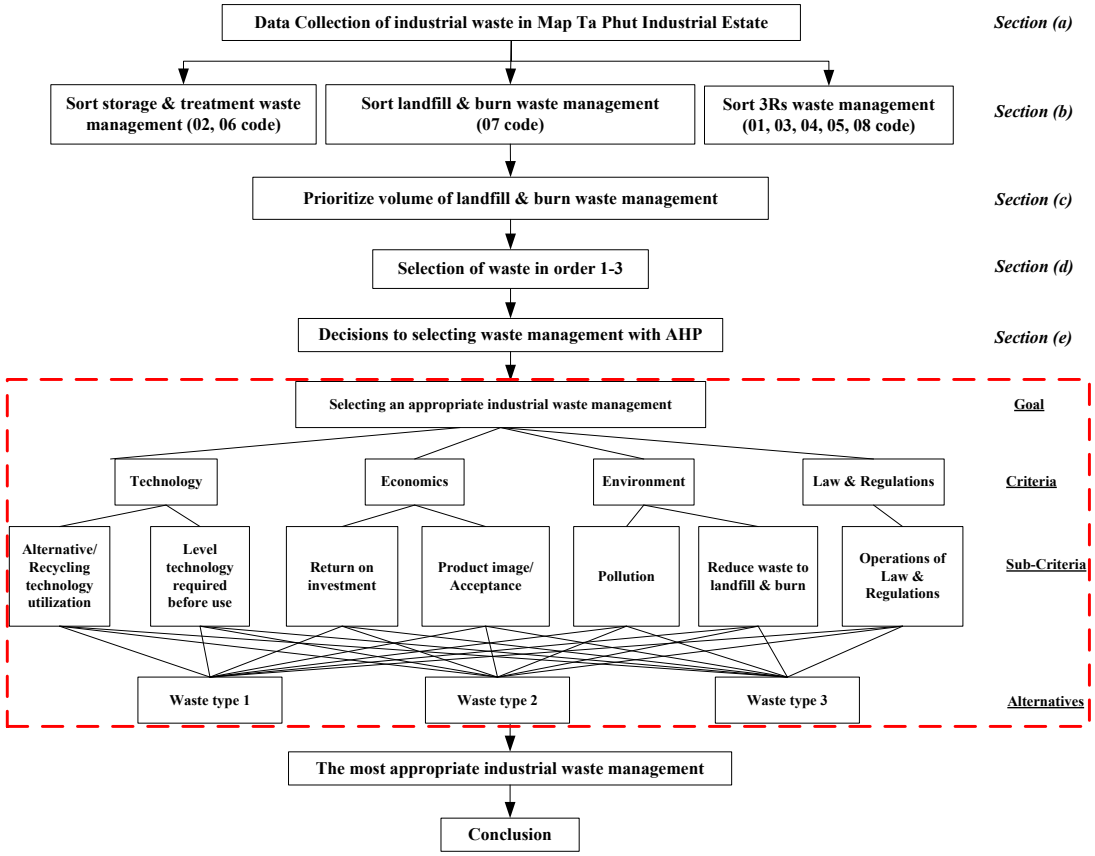

Fig. 1 Flow chart of selecting an appropriate industrial waste management

(a) Collect data on waste type, waste quantity, waste management method, and resources provide waste management for plants in Map Ta Phut Industrial Estate.

(b) Analyze waste management method by categorizing waste management method into 3 groups which are waste management method using 3Rs principal (Reduce, Reuse, Recycle) (Code

01, 03, 04, 05 and 08), Storage and Treatment (Code 02 and 06), and elimination by landfill and burn (Code 07) (Note: Waste management code specified by the Ministry of Industry).

(c) Ranking waste by quantity of waste eliminated by landfill and burn methods.

(d) Select waste from 1 to 3 respectively as alternatives for AHP method.

(e) Calculate AHP value by applying Expert Choice program.

Experimental research

After following step (a) to (d), In Map Ta Phut Industrial Estate, the industrial waste quantity from 2014 is 3,802,513.72 tons/year dividing into waste eliminated by 3Rs principle of 3,429,980.08 ton/year, storage and treatment of 17,350.20 ton/year, landfill and burn of 355,183.44 ton/year. Ranking the total waste eliminated by landfill and burn in hierarchy, we found that the top three are wastewater sludge, EAF dust, and Rockwool insulation respectively. These will be used as alternatives in step (e) and applied with Expert Choice program as follow.

Step 1: AHP model construction

Construct AHP model in Expert Choice (Fig. 2) by specifying objective, main criteria, sub-criteria and alternatives respectively.

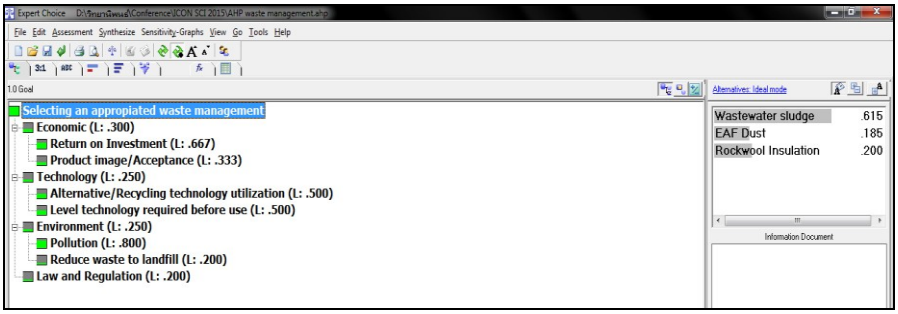

Fig. 2 AHP model construction in Expert Choice

Step 2: Pair-wise comparison

The group consistency will be calculated for geometric mean in hierarchical significance from 1-9 in comparison for significance of main criteria and sub-criteria. Then, we will check data weight's consistency. The consistency ratio (CR) must not be over 0.1. If the CR is not over 0.1, it is considered that the data is consistent and acceptable. If the CR is over 0.1, it is advised to review and adjust the data weight. According to the analysis result of the pair-wise comparison on hierarchical significance of 4 criteria, it is found that the 4 criteria have a full consistency (CR=0). The economic factor shows the highest significance of 0.30, followed by technology and environment at the same significance of 0.25, and laws and regulations at 0.20 respectively.

Step 3: Alternatives ranking

According to the analytic hierarchy process to find the hierarchical significance on waste management, it is found that wastewater sludge is the most suitable waste based on the 4 main criteria. Thus it ranks the first to be selected (0.615), followed by Rockwool insulation (0.200) and EAF dust (0.185) respectively.

Step 4: Sensitivity Analysis

The sensitivity analysis on the 4 main criteria is the process to check the waste's hierarchy change of significance whether there is any change on value of significance weight of the criteria. This is displayed as a graph showing alternatives significance value in vertical Y and weight value of criteria significance in horizontal X. The result of analysis on gradient sensitivity of the 4 criteria indicates that if the value of economic significance weight equal to 0.3, the wastewater sludge ranks the first by selection. EAF dust and Rockwool insulation are also sensitive to change of the value of economic significance weight. If the weight value increases more than 0.65, the Rockwool insulation will be in the third rank of selection instead of EAF dust which will be in the second rank of selection.

As for technology, there is a change on selection hierarchy of EAF dust and Rockwool insulation if the significance weight value increases more than 0.80. For environment, laws and regulations, there is a change on selection hierarchy of EAF dust and Rockwool insulation if the significance weight value decreases lower than 0.07 and 0.10 respectively.

Conclusion

This research emphasizes on developing a procedure on prioritize and selecting industrial waste management method by applying AHP.The result of this case study found that the experts focus on economics the most that is equal to30%, followed by the technology 25%, environment 25%, law and regulations 20% respectively. As a result of the research, we can develop decision support process to enable a proper selection of waste management method according to objectives and covers factors in economics, technology, environment, laws and regulations. To evaluate the result, we must be careful in setting the significance weight value of the criteria as it will directly affect significance hierarchy of the alternatives. However, this decision support process can be applied with other industrial estates in order to manage waste more effectively and upgrade the industrial estates to be sustainable Eco Industrial Towns in the future. For further enhanced research in the future, we should consider other factors which are significant to decision making on selection of waste for a proper management in each industrial estate such as social aspect which requires lots of questionnaire to reflect needs of people around the industrial estates. This will create a full participation on the selection decision making. Besides, we should increase the number of specialists and stakeholders to cover all concerning area which will make this prioritizing and selecting industrial waste management method by applying AHP obtain higher confidence and effectiveness.

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