DEVELOPMENT OF SOCIO - ECO - EFFICIENCY INDICATORS FOR ASSESSMENT OF INDUSTRIAL WASTE FROM INDUSTRIAL ESTATE IN MAP TA PHUT AREA, RAYONG PROVINCE, THAILAND

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ABSTRACT

The Industrial waste problem in Thailand is an important issue that should be managed urgently especially in the large industrial areas that are causing a lot of industrial waste each year. This study presents the development of Socio-Eco-Efficiency indicators for the assessment of industrial waste from the Map Ta Phut Industrial Complex (MTPIC) area, which consists of four industrial estates, Map Ta Phut industrial estate (MTPIE), Padang industrial estate (PIE), Hemaraj Eastern industrial estate (HEIE), and Asia industrial estate (AIE). All of these estates are located in Rayong province in eastern Thailand. The data of industrial waste was generated from the four industrial estates between 2006 and 2008. All of the data was gathered from the electronic waste management online system, Ministry of Industry, monitoring report, and data that was available at the Industrial Estate Authority of Thailand. Waste Flow Analysis was applied as a method for characterizing industrial waste that created the waste flow diagram and calculated the 3R waste ratio.

The Socio-eco-efficiency was analyzed by weighting the social issue about waste management and was calculated into the Socio-Eco-Efficiency equation. It is concerned about the impact and benefits of environmental, economic, and social dimension.

The results show that 3R waste (81.33 %) is the higher proportion when compared with disposal waste (81.33 %) and sludge (72.18 %) was the highest component. The most disposal sludge was sent to be treated by the landfill and most 3R sludge was used for land reclamation. When we consider the 3R waste ratio, PIE was 0.854, which means PIE had the highest potential to become an eco-industrial estate, and this defines the close loop material model. The highest Socio-Eco-Efficiency was HEIE at about 170.80 and the second was PIE which was the same as the eco-efficiency result. The trend of socio-eco-efficiency of MTPIC in 2008 increased by about 104.48 % when compared with 2006 and 44.87 % when compared with 2007. However, the main result of this research is the method for developing Socio-Eco-Efficiency indicators for sustainability.

KEY WORDS: SOCIO-ECO-EFFICIENCY/ 3R WASTE/ ECO-EFFICIENCY INDICATOR/ INDUSTRIAL ESTATE/ MAP TA PHUT INDUSTRIAL COMPLEX

89 pages

การพัฒนาดัชนีชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจ สังคม สำหรับการประเมินกากของเสียอุตสาหกรรมที่เกิดจาก นิคมอุตสาหกรรมในเขตพื้นที่มาบตาพุด จังหวัดระยอง ประเทศไทย

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คณะกรรมการที่ปรึกษาวิทยานิพนธ์ : กิติกร จามรดุสิต, Ph.D. (Chemical Technology), กัมปนาท ภักดีกุล, Ph.D. (Civil and Environmental Engineering), จำลอง อรุณเลิศอารีย์, Ph.D. (Fisheries)

บทคัดย่อ

ปัญหากากของเสียอุตสาหกรรมในประเทศไทยเป็นประเด็นสำคัญที่ควรจะได้รับการบริหารจัดการเป็นพิเศษ โดยเฉพาะในเขตพื้นที่อุตสาหกรรมขนาดใหญ่ งานวิจัยนี้นำเสนอการพัฒนาดัชนีชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจ สังคม สำหรับการประเมินกากของเสียอุตสาหกรรมที่เกิดจากนิคมอุตสาหกรรมในเขตพื้นที่มาบตาพุด จังหวัดระยองซึ่งประกอบไปด้วย4 นิคมอุตสาหกรรม ได้แก่ นิคมอุตสาหกรรมมาบตาพุด (MTPIE) นิคมอุตสาหกรรมผาแดง (PIE) นิคมอุตสาหกรรมเหมราชตะวันออก (HEIE) และนิคมอุตสาหกรรมเอเชีย (AIE) โดยอาศัยข้อมูลทุติยภูมิของกากของเสียอุตสาหกรรมปี พศ. 2549 – พ.ศ. 2551

ประสิทธิภาพเชิงนิเวศเศรษฐกิจ สังคม (Socio-eco-efficiency) ทำการวิเคราะห์โดยการให้ค่าคะแนน จากการให้ค่าถ่วงน้ำหนักประเด็นทางการยอมรับทางสังคม เกี่ยวกับ การจัดการกากของเสีย ความพึงพอใจ และความคิดเห็นของประชาชนจากการสำรวจความคิดเห็นของประชาชนโดยรอบแหล่งบำบัดกากของเสียอุตสาหกรรม

ผลการวิจัยระบุว่า ปริมาณกากของเสียอุตสาหกรรม 3R มีสัดส่วนมากกว่ากากของเสียอุตสาหกรรมเหลือทิ้ง คือประมาณ 81.33 % เมื่อเทียบกับปริมาณกากของเสียอุตสาหกรรมทั้งหมดและกากของเสียอุตสาหกรรมประเภทกากตะกอน (Sludge) มีปริมาณมากที่สุด 72.18 % เมื่อเทียบกับปริมาณกากของเสียอุตสาหกรรมทั้งหมด โดยกากของเสียอุตสาหกรรมประเภทกากตะกอน 3R ส่วนใหญ่นำกลับ ไปใช้ใหม่โดยการนำไปเป็นส่วนหนึ่งในการถมที่ดิน(Land reclamation) และนิคมอุตสาหกรรมเหมราชตะวันออกมีค่าประสิทธิภาพเชิงนิเวศเศรษฐกิจ สังคมสูงที่สุดคือ 170.80 รองลงมาได้แก่นิคมอุตสาหกรรมผาแดงและนิคมอุตสาหกรรมมาบตาพุด ซึ่งผลการวิจัยหลักในครั้งนี้คือการนำเสนอแนวทางการพัฒนาตัวชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจ โดยรวมมิติทางสังคมเข้ามาในการประเมินตามหลักการพัฒนาอย่างยั่งยืน

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LIST OF ABBREVIATIONS

3R	-	Reuse Recycle Recovery
3RWR	-	3R Waste Ratio
AIE	-	Asia Industrial Estate
Avg.	-	Average
BASF	-	Badische Anilin- und Soda-Fabrik (Baden Aniline and Soda Factory)
EUR	-	Euro (Currency)
HEIE	-	Hemaraj Eastern Industrial Estate
IEAT	-	Industrial Estate Authority of Thailand
LCA	-	Life Cycle Assessment
MFA	-	Material Flow Analysis
MTPIC	-	Map Ta Phut Industrial Complex
MTPIE	-	Map Ta Phut Industrial Estate
PIE	-	Padaeng Industrial Estate
PPPs	-	Public private partnerships
SD	-	Standard Deviation
US$	-	US Dollar
WBCSD	-	World Business Council for Sustainable Development
WMS	-	Waste Management System

CHAPTER I
INTRODUCTION

1.1 Background and significance

Since the industrial revolution, industrial operations and development have been accompanied by a problem, industrial waste which may be toxic, ignitable, corrosive or reactive. This waste is generated at every stage in the production process. Industrial waste can be classified into two major categories as hazardous industrial waste and non - hazardous, hazardous waste refers to solid, liquid or gaseous wastes, that harmful, such as highly flammable, corrosive, highly reactive or toxic substances, which also include treated hazardous waste, non - hazardous waste refers to wastes that generated in manufacturing or production that are not harmful to humans, property or the environment [1].

From the Thailand Ministry of Industry report, the amount of industrial waste in Thailand in year 2007 was about 37.7 million ton per year can divide into non - hazardous waste about 32.7 million ton and hazardous waste about 5 million ton and the trend also increase every year. If improperly managed, this waste can pose dangerous health and environmental consequences especially in case of hazardous waste that must be managed with extreme care to avoid adverse environmental or human health impacts and one efficiently alternative for industrial waste management was waste reduction. A reduction of waste volume required effective and appropriate management. When management was appropriate its will benefit to both economic and environment. In appropriate waste management, waste reduction is the most important factor by reuse, recovery, recycle and disposal is an element that made waste management become effective [2]. Waste reduction is a technique or activities that reduce waste volume from source or production unit [3], changing practices and processes to reduce or eliminate the generation of wastes and materials. Some source reduction methods include chemical substitution, process modification, and improved operating procedures If the implementation of these method actually used its will reduce pollution and waste volume that occurs.

In the recent year, the Eco-efficiency assessment is widely use and accepted for industrial sector and any business because it can increase efficiency of competition and assess the efficiency of environmental dimension and economic dimension together. The concept of eco-efficiency was developed by the World Business Council for Sustainable Development (WBCSD) in 1992 and has become widely recognized by the business world. It brings together the essential ingredients, economic and environmental progress, which necessary for economic prosperity to increase with more efficient use of resources and lower emissions [4]. Eco-efficiency was importance for competition potential, process management was considered with economic and ecology efficiency that key of competitive capacity increasing of all business. But in the near future, the emphasis of industrial efficiency only environmental and economic efficiency is not enough because it does not cause sustainable development, then the social assessment is required to participate for the cause of sustainable industry.

Sustainable development can creates opportunities for supplier of green consumers, developers of environmentally safer materials and processes, firms that invest in eco - efficiency, and those that engage themselves in social well-being. These enterprises will generally have a competitive advantage. They will earn their local community's goodwill and see their efforts reflected in the bottom line. The creation of eco-efficiency balance is means an effort to create between 2 elements that economic and ecology by based on principle of maximization economic value and sufficient natural resource consumption with minimum environmental impact which will lead to better quality of life of people living around and public that approach to sustainable development. So environmental problems was received more attention from the industrial sector but because of continued economic growth occur, demand of natural resource increase, resulting pollution and waste volume from industrial sector increase. So reducing waste was important factor that use for reduce environmental problems.

In this study, some part of principle of Material Flow Analysis was used to study flow of waste in the case of industrial waste that occurs from industrial estate in

Map Ta Phut area, Rayong province and analyze eco-efficiency by take the social dimension evaluate in the equation. This study area is high investment from both local and international organization results to increase of waste and pollution in many form and affect around people both physical and psychological cause many complaints problem including the effect of national economic change. Industrial estate in Map Ta Phut Complex area (MTPIC) consists of four industrial estates, Map Ta Phut industrial estate (MTPIE), Padaeng industrial estate (PIE), Hemaraj Eastern industrial estate (HEIE), and Asia industrial estate (AIE), located in Rayong province, eastern of Thailand. Data of industrial waste generated from the four industrial estates from year 2006-2008 was gathered from the electronic waste management online system, Ministry of Industry, monitoring report, and data available at the Industrial Estate Authority of Thailand. Some part of Material flow analysis was applied to be as a method for characterized an industrial waste and created the waste flow diagram and analyze the eco-efficiency by weighting the social issue about waste management and calculate in socio-eco-efficiency equation of industrial waste from industrial estate in Map Ta Phut Complex area including disposal and 3R waste with concern of impact and benefits of environmental, economic, and social dimension.

1.2 Research objective

The objective of the study is to develop the socio-eco-efficiency indicator that can assessed the efficiency of industrial waste generation from factories in the Map Ta Phut Complex area, Rayong province.

1.3 Hypothesis

Socio-eco-efficiency assessment can evaluate waste assessment for approach sustainable development.

1.4 Scope of research

1.3.1 Scope of study area

This study use Map Ta Phut Complex area that consists of four industrial estates, Map Ta Phut industrial estate (MTPIE), Padaeng industrial estate (PIE), Hemaraj Eastern industrial estate (HEIE), and Asia industrial estate (AIE), located in Rayong province, eastern of Thailand as the study area

1.3.2 Scope of data

This study use secondary data of waste occurs from industrial estate in Map Ta Phut Complex area, Rayong province from 2006 – 2008 and use data base from the electronic waste management online system, Ministry of Industry.

1.3.3 Scope of methodology

The methodology is development of the socio-eco-efficiency indicator by characterize an industrial waste from industrial estate in Map Ta Phut Complex area including disposal and 3R waste and create the waste flow diagram by add the social dimension into the eco-efficiency calculation. Then evaluate and analyze the results by use the appropriate social weighting scenario in calculation and conclude by compare the socio-eco-efficiency results of each industrial estate.

1.5 Conceptual framework

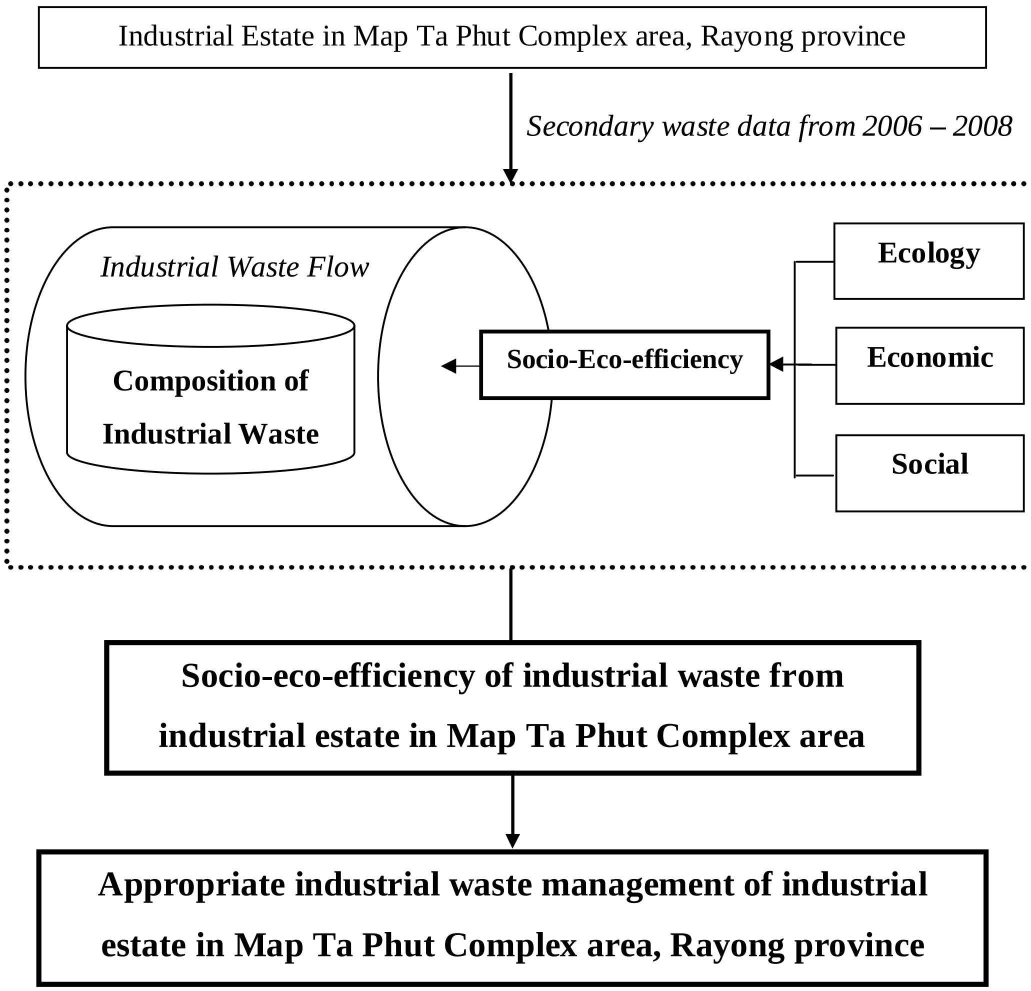

Figure 1.1 The conceptual framework

1.6 Outcomes

The approach of socio-eco-efficiency indicator include social acceptation dimension that use to evaluate industrial sector and lead to planning industrial waste management more efficiently.

CHAPTER II
LITERATURE REVIEW

In this literature review is a gathering of theory that associated with this research for more understand. The main issue in this research is include

2.1 Sustainable Development
2.2 Eco-efficiency
2.3 The public health impact of waste on Human
2.4 Map Ta Phut Industrial Complex
2.5 Relevant Research

2.1 Sustainable Development

The sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [5]. The attainment of sustainability requires the incorporation of three interlinked endeavors as economic, environmental, and social [6] shown in Figure 2.1

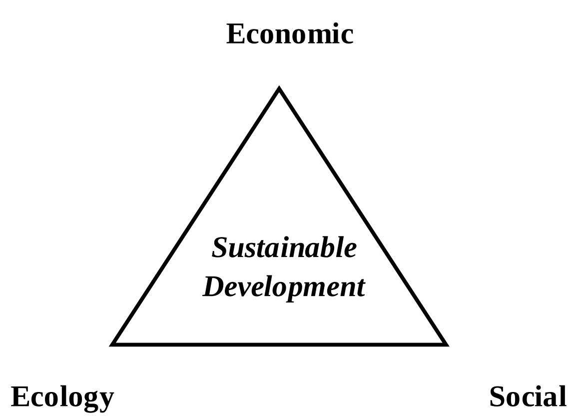

Figure 2.1 Sustainable development triangle

In order to make progress towards sustainability, all three of economic development, environmental protection and societal good have to be improved. If, for instance, we can identify pollution avoidance, economic value – added, and societal good as the apexes of triangle (Figure 2.1), progress towards sustainability would imply an increase in the surface area of the triangle [6].

2.1.1 Sustainable Industrial Development

Successful and sustainable industrial development is largely a function of a vibrant private sector operating in a market-oriented framework. In this regard, conductive enabling frameworks are critical both for local business communities and for foreign investment. Further, cooperation between business and governments, with understanding of their respective roles and responsibilities, is crucial.

Industrial development and society's environmental and other societal goals should be pursued in a harmonious manner. Through industrial development, business: [7]

1) Provides products and services not only for consumers but also along the entire supply chain including to other businesses and the public sector

2) Shares good practices

3) Contributes to societal capacity in capital equipment, know-how and skilled employees

4) Creates jobs and contributes to capacity-building

5) Builds and maintains infrastructure (for energy and water, among others)

6) Grows new opportunities for economic growth at local and regional levels

7) Promulgates accountable and transparent environmental and other management systems, cleaner production and eco-efficiency

8) Generates resources needed to finance social needs, for example tax revenues to public authorities

9) Engenders capacity to design and implement technological innovation and cooperation.

Indeed, a successful industrial base strengthens society and contributes to the capacity to pursue sustainable development. Building a sustainable future will require tapping and enabling the capabilities and resources of all to invent, manage, empower and cooperate. Industrial development is an important pathway in that regard.

Industrial development will be slowed by the lack or poor condition of infrastructure in areas such as water, energy, telecommunications and road systems. Infrastructure development is a priority concrete area where public and private sectors can work together through public private sector partnerships. For such partnerships (Public private partnerships: PPPs) to succeed: [7]

1. The legal framework needs to enable the entrance and operation of private entities in what are often state-controlled industries;

2. The coordination of preparatory measures for efficient PPP start-up and implementation is necessary;

3. The allocation of risks through contractual agreements needs to be addressed. While considering measures to facilitate PPPs, it is important to note that project profitability is a vital prerequisite for private sector involvement, especially if the project requires long-term engagement.

2.2 Eco-efficiency

Eco - efficiency was importance for competition potential, process management was considered with economic and ecology efficiency that key of competitive capacity increasing of all business. Resources use and lower of waste discharge, water and energy saving, the improvement of occupational health and safety can decrease operation cost, in addition, also lead to operation form that consists with business ethics. Then the increasing of eco - efficiency was a preparing to operators to perform the full range following social standard and environmental that was a conditions of international trade [8]. The competition need to recognize with the impact on ecosystems and natural resources at the level that must be at least consistent with the ability of the carrying capacity of the competition. [9]

The World Business Council for Sustainable Development (WBCSD) defined eco-efficiency as “Eco - efficiency is achieved by the delivery of competitively - priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth s estimated carrying capacity” [10]. Eco - efficiency has been defined as a general goal of creating value while decreasing environmental impact. Leaving out the normative part of this concept, the empirical part refers to a ratio between environmental impact and economic cost or value. Two basic choices must be made in defining practical eco - efficiency: which variable is in the denominator and which is in the numerator; and whether to specify environmental impact or improvement and value created or cost. Distinguishing between two situations, the general one of value creation and the specific one of environmental improvement efforts, and leaving the numerator – denominator choice to the user, as diverging practices have developed, four basic types of eco-efficiency result: environmental intensity and environmental productivity in the realm of value creation; and environmental improvement cost and environmental cost-effectiveness in the realm of environmental improvement measures. The WBCSD has identified seven elements that businesses can use to improve their eco - efficiency as follow [11].

1. Reducing material intensity
2. Minimizing energy intensity
3. Reducing dispersion of toxic substances
4. Undertake recycling
5. Capitalizing on use of renewable
6. Extending product durability
7. Increasing service intensity

These seven elements may be thought of as being concerned with three objectives as; [11]

1. Reducing the consumption of resources: This includes minimizing the use of energy, materials, water and land, enhancing recyclability and product durability, and closing material loops.

2. Reducing the impact on nature: This includes minimizing air emissions, water discharges, waste disposal and the dispersion of toxic substances, as well as fostering the sustainable use of renewable resources.

3. Increasing product or service value: This means providing more benefits to customers through product functionality, flexibility and modularity, providing additional services (such as maintenance, upgrading and exchange services) and focusing on selling the functional needs that customers actually want. Selling a service instead of the product itself raises the possibility of the customer receiving the same functional need with fewer materials and less resources. It also improves the prospects of closing material loops because responsibility and ownership, and therefore concern for efficient use, remain with the service provider.

The WBCSD was divided eco-efficiency into two indicators as follow, [12]

1. Generally applicable indicators can be used by virtually all businesses. As well as being more or less universal relevant, each of these indicators relates to a global environmental concern or business value and methods for measurement are established and definitions accepted globally. For example, quantity of goods or services produced or provided to consumers or net sales. While, general indicator for environmental impact as energy consumption, water consumption, wastes, greenhouse gas emissions, and ozone depleting substance emissions.

2. Business specific indicators means they are more likely to be individually defined from one business or one sector to another. These indicators are not necessarily less important than the first group. That judgment will depend on the nature of an individual business. They are merely less widely applicable. A company's eco-efficiency performance profile will include both types of indicators. Example of these indicators was gross margin, waste to landfill, and waste to incineration.

2.2.1 Choices in Eco-efficiency terminology

The starting point for the formal definition of eco - efficiency is the general definition of WBCSD that describe eco-efficiency as a ratio between two elements: environmental impact, to be reduced, and value of production, to be increased. The value of production lies in the products produced, comprising both goods and services.

Two equivalent variants are used, the ratio of value to environmental impact and the ratio of environmental impact to value, one being the exact inverse of the other, but with the same information content. In addition to the creation of maximum value with minimum environmental impact, there is the analysis of dedicated environmental improvements. The focus then shifts from the creation of value to the reduction of cost for the environmental improvements investigated. The signs of both numerator and denominator then reverse, or the variables are defined in the opposite direction. This distinction between the analysis of value creation and the analysis of environmental improvements can be combined with the inversion options. It seen wisest to make eco-efficiency an overarching general concept, with variants under this overarch.

Table 2.1: Four basic variants of eco-efficiency

	Product or production prime	*Environmental improvement prime*
Economy divided by environmental	Production/consumption value per unit of environmental impact: **1. environmental productivity**	Cost per unit of environmental improvement: **3. environmental improvement cost**
Environmental divided by economy	Environmental impact per unit of production/consumption value or: **2. Environmental intensity**	Environmental improvement per unit of cost **4.environmental cost-effectiveness**

The relationship of these variants is shown in Table 2.1 In actual applications, there often is not a full system being analyzed but a difference analysis between options is performed, with positive and negative results depending on which situation is taken as a reference. For example, in a win - win situation resulting from technological improvement, described as a difference from the current or not improved future situation, the denominator of environmental productivity becomes negative, as then does the ratio itself. Similarly, some environmental improvements may not entail cost but reduce cost as, for example, by creating additional value. Then the environmental cost - effectiveness becomes negative. Making separate categories also for these cases would lead to a confusingly large number of terms, because, for each of four basic options, the sign of the numerator of the dominator, or of both may change. If all these situations were really distinguished, sixteen options would result.

2.2.2 Eco – efficiency for sustainability

Sustainability refers to reconciling environmental, economic and social concerns both from a current point of view and long term intergenerational perspective. Making the jump from concept to tool is loaded with ethical-normative and practical modeling complexities, which cannot be resolved in a broadly acceptable way. Different options exist, for example, on the exchanges allowable between the economic and ecological domain, reflected in positions on very strong to very weak sustainability. Eco - efficiency analysis as advocated here does not take a stance on such issues but tries to straighten out the underlying empirical analysis which may show that we are on a path of very strong or of very weak sustainability. To be open to such different options it is essential not to aggregate environmental and economic aspects, but leave them as separate entities as one input into the discussion on strong versus weak sustainability. However, in using eco - efficiency analysis for practical decision support at a micro level of specific firms, products and technologies, and for policies related to these, some link to an encompassing concept of sustainability has to be established, as limited as possible to be open to different positions, but allowing for some broadly agreed upon practical guidance. In simple situations, choices may be clear as when between two options one is superior both in environmental and in economic terms. A simple dominance analysis then some trade - off between economy and environment is involved. Guidance on the trade - off can be given based on broadly accepted assumptions. There is broadly support for the position that economic growth should not lead to a deteriorating environmental quality, reflecting a not so strong sustainability point of view.

2.3 The public health impact of waste on Human

The public health impacts are determined by the overall waste management strategy adopted locally, regionally and nationally. The waste management could have an impact on health as follow. Directly, by leading to potential adverse or beneficial health impacts such as increased risk of cancer or decreased quality of life. Indirectly, the broader environmental impact on the global ecology such as the contribution to global warming, loss of bio-diversity and the depletion of non - renewable resources. The type of health problems experienced by people around waste facilities and those experienced by people nowhere near a waste facility are basically the same. Health effects are non - specific. The human body has only a limited number of responses to a wide range of internal and external assaults. Contaminant levels and individual susceptibility determine which responses occur [13].

2.4 Map Ta Phut Industrial Complex

Map Ta Phut Industrial Complex area (MTPIC) is a macro scale petrochemical and chemical industrial area with high investment and crucial to the economic changes in Thailand, which consists of four industrial estates including Map Ta Phut Industrial Estate (MTPIE), Padaeng Industrial Estate (PIE), Hemaraj Eastern Industrial Estate (HEIE), Asia Industrial Estate (AIE), located in Rayong province, eastern of Thailand. Map Ta Phut Industrial Complex is located in Muang District, Rayong province. There are 5 Tambons in the municipality, Map Ta Phut Municipality, Tambon Huaypong, and some areas of tambon Tabma, Tambon Mabkha, and Tambon Nurnpra. Map Ta Phut Municipality covers a total area of 148.96 square kilometer. The north, the municipality borders Tambon Mabkha, Bankai District, Rayong province. To the east it borders Tambon Nurnpra, Tabma, Muang District, Rayong province. To the west, it shares border with Ban Sang District, Rayong Province, and to the south it borders the Gulf of Thailand [8]. From the Map Ta Phut industrial estate, Industrial Estate Authority of Thailand, the number of factories in Map Ta Phut Complex area in March, 2008 was 116 factories, divided into

MTPIE was 65 factories, PIE was 5 factories, HEIE was 36 factories and AIE was 10 factories.

2.5 Relevant Research

Kharel and Charmondusit [14] presented the eco - efficiency of energy intensity, material consumption, water use, waste generation, and CO_2 emission in terms of production value in net sales (US$) per environmental influence using empirical evaluation. This study has scoped and confined the boundaries of production processes in iron rod industry in order to distinguish eco - efficiency measurements and to improve situation. The ultimate aim of eco - efficiency is to scrutinize activities with evaluation to improve the performance of industry. Eco - efficiency of iron rod industry was quantitatively analyzed and determined that energy, material consumption, water use, waste generation, and CO_2 emission eco - efficiency have been increased gradually along with increased production during analysis period of five years (2001 - 2005). It was possible due to installing heat recovery unit along with innovative processes modification. While comparing each year's eco - efficiency of all above - mentioned parameters, eco-efficiencies were increased that indicates less resource use and less waste released. As a general statement of overall comparison and characterization of eco - efficiencies of five years duration, iron rod industry was eco - efficient in all aspects.

Saling et al. [15] studied eco - efficiency analysis by BASF: The method by the aim of the research is the development of a common tool, which is usable in a simple way by LCA experts and understandable by a lot of people without any experience in this field. The results should be shown in such a way that complex studies are understandable in one view. The method belongs to the rules of ISO 14040. Beyond these life cycle aspect costs, calculations are added and summarized together with the ecological results to establish an eco – efficiency portfolio and the results of the studies are shown in a simple way, the eco – efficiency portfolio. Therefore, ecological data are shown that the weighting factors, which are used in our method, have a negligible impact on the results. In most cases, the input data have an important impact on the results of the study. This studies conclude that its could be shown that the newly developed eco – efficiency analysis is a new tool, which is usable for a lot of problems in decision – making processes. It is a tool which compares different alternatives of a defined customer benefit over the whole life cycle. This paper recommended that this method can be used in research and development as well as in the optimization of customer processes and products. It is an analytical tool for getting more sustainable processes and products in the future.

Saling et al. [16] assessing the environmental - hazard potential for life cycle assessment, eco - efficiency and SEEbalance®. This paper describe that BASF has developed the eco – efficiency analysis tool to address not only strategic issues but also issues posed by the marketplace, politics and research. The goal was to develop a tool for supporting decision - making processes, which is useful for many of applications in the Chemical and other industries. A part of eco – efficiency analysis involves the evaluation of the toxicity and ecotoxicity potential. SEEbalance® is an instrument that includes an assessment of a product's social impacts in addition to the economic and environmental ones and an issues that used in this research evaluation were energy consumption, use of area, resources consumption, emissions, risk potential, and environmental – hazard potential. If using SEEbalance® assessment instead the eco – efficiency assessment, the environmental – hazard potential issues will be adjusted to the social dimension and result will showed in ecological fingerprint, shown in Figure 2.4

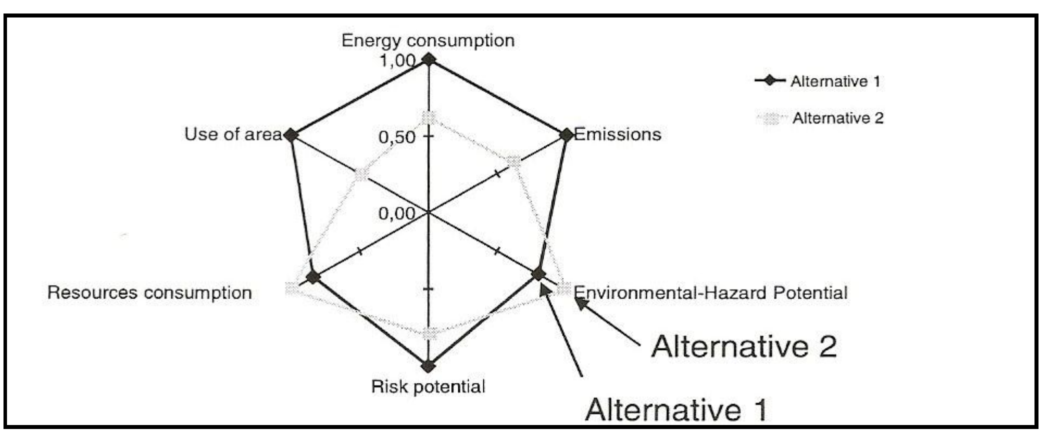

Figure 2.2 Ecological fingerprint of Eco – efficiency analysis and SEEbalance® [26]

Schmidt [17] studied managing socio – efficiency of products and processes further development of the BASF eco – efficiency analysis by the social sustainability dimension. The aim of this paper are to work out a conceptual framework in further developing the life cycle assessment procedure of the BASF eco – efficiency analysis by supplementing the social sustainability dimension, to develop product – related social assessment criteria from the sustainability debate, to build up a product – related database for the social life cycle assessment procedure, and to test the suitability of the assessment procedure that has been developed in practice by way of two typical examples. This paper multiplied with the social dimension from weighting value in the equation 1.

$$\text{Socio–Efficiency} = \frac{\text{Social benefit from a product throughout the entire life cycle}}{\text{Total costs of ownership [EUR]}} \quad \ldots (1)$$

The social dimension in a part of social benefit from a product/process throughout the entire life cycle came from a calculation in Equation 2.

$$\text{Total Assessment Factor} = \text{National Relevance Factor} \times \text{Subjective Assessment Factor} \quad \ldots (2)$$

By the national relevance factor to be calculated from national statistics and subjective assessment factor came from polls. This paper concluded that the above observations show that the claim to develop an assessment procedure for the social sustainability of products and processes involves great theoretical and practical difficulties. These are due to the high complexity and indefiniteness of the social sustainability dimension, to questions on the method of the assessment and aggregation procedures and finally to very practical obstacles, such as the availability of data and the acceptance of the procedure in the company and by the public. There is also the question of defining the system boundaries in a meaningful way. A differentiation is to be made between direct effects, such as the creation of jobs, and the numerous effects resulting indirectly from these, which cannot be examined within the framework of this assessment instrument. Although I know full well the problems that can in my opinion not completely be solved, only the attempt can be made to create an instrument in the sense of best available practice – as in the case of life cycle assessments and other instruments of eco - controllings. The procedure to be developed is regarded as “work in process”, which means that it should always be critically reviewed and developed further in line with the ongoing political and scientific discussion.

Huppes [18] studied the realistic Eco – efficiency analysis in the topic of why we need better eco – efficiency analysis: from technological optimism to realism. This studied describe that Eco-efficiency analysis relates two pillars of sustainability, the economic and the environmental one. There are several options for specifying eco-efficiency, as a partial or more encompassing concept. When using technology specification as the basis for eco-efficiency analysis, there is an inbuilt tendency towards unjustified optimism, as other societal mechanisms detract from the technology potential. A more systematic approach to modelling is required to arrive at a more realistic analysis, both lining the micro level analysis to the macro level sustainability consequences for society and reckoning with the relevant mechanism in society of economic, cultural, institutional and political nature. With more realistic modelling, more realistic requirements on the trade-off between economy and environment at a micro level can be formulated. Eco-efficiency analysis can support sustainable decision making by giving insight in the trade-offs as exist or are expected to be involved empirically, and by creating the option of specifying the minimum trade-offs which are required for sustainable development, covering the economic and environmental aspect. In supporting this eco - efficiency analysis, options for modeling economic, socio - cultural and institutional and regulatory mechanisms are to be taken into account, beyond the mere technological relations as now used in LCA. Decoupling is a related concept at the macro level, stating the environmental effectiveness of developments towards sustainability.

Huppes and Ishikawa [19] studied eco – efficiency and its terminology describe that Eco - efficiency has been defined as a general goal of creating value while decreasing environmental impact. Leaving out the normative part of this concept, the empirical part refers to a ratio between environmental impact and economic cost or value. Two basic choices must be made in defining practical eco - efficiency: which variable is in the denominator and which is in the numerator; and whether to specify environmental impact or improvement and value created or cost. Distinguishing between two situations, the general one of value creation and the specific one of environmental improvement efforts, and leaving the numerator-denominator choice to the user, as diverging practices have developed, four basic types of eco - efficiency result: environmental intensity and environmental productivity in the realm of value creation; and environmental improvement cost and environmental cost - effectiveness in the realm of environmental improvement measures.

Meneses, Rodrigo and Castells [20] studied Assessment tool for waste management system: Consideration of social aspects. This paper describe that the assessment tool is a visual basic interface that allows the user to evaluate and compare the three sustainability aspects, environmental, economic and social, for a Waste Management System, WMS up to four system by means of a inputs variables. A comparison of two different WMS scenarios, by means of the mentioned tool, is presented in this work giving special emphasis to the social assessment which is considered an innovative issue. The social criteria and indicators are classified under three perspectives; the social acceptability, equity and function of the WMS. A set of 13 social criteria has been selected within the three main stages of the WMS: temporary storage, collection and transport system, and pre-treatments and treatments. In order to quantify these criteria, a set of indicators has been developed. The indicator evaluated are; odour, visual impact, comfort, urban space, private space, noise, complexity, traffic, risk perception, distribution and location, employment quality, employment creation and final destination.

CHAPTER III
METHODOLOGY

In the research of development of Socio–eco–efficiency indicators for assessment of industrial waste from industrial estate in Map Ta Phut Complex area, Rayong province, use the industrial waste generated from the four industrial estates data from year 2006 – 2008. This chapter is about the methodology including four main steps as;

3.1) Data collection
3.2) Characterization of industrial waste in the MTPIC
3.3) Development of Socio-Eco-efficiency indicator for industrial waste and data analysis

3.1 Data Collection

Data collection was mainly done through field site investigation. Characteristic data of hazardous and non – hazardous industrial waste generated from the four industrial estates (MTPIE, PIE, HEIE, and AIE) located in the MTPIC area from the year 2006 to 2008 was received from the electronic waste management online system, Ministry of Industry, existing monitoring report and database at the Industrial Estate Authority of Thailand (IEAT). The gathered data was separated into two categories, which were 3R (reuse, recycle, and recovery) waste and disposal waste. Twelve components of each industrial waste categories were characterized including paper, wood, rubber, plastics, metal, oil, sludge, electronic, chemical, waste water, glass and other.

3.2 Characterization of industrial waste in the MTPIC

1.) Grouping waste data in each industrial estate into 2 groups as; reuse, recycle, and recovery (3R) waste and disposal waste for facilitate of analysis and waste flow diagram creation.

2.) Summarize total industrial waste for creation of waste flow diagram

3.) When all of industrial waste data was collected, then use it to create waste flow diagram of Industrial Estate in Map Ta Phut Complex area by divide group of industrial waste into 2 categories. Firstly, 3R waste, which is including of reuse, recycle, and recovery waste, that waste were the conversion of waste to resources. Secondly, disposal waste which waste is brought to eliminate by landfill, burn in incinerator, co - incineration in cement kiln, collect and export, land reclamation, and other. The two categories of industrial waste were classified by reference from treatment and disposal code in the monitoring report. The important details in the monitoring report comprise of waste code, hazardous property, name, amount, and treatment or disposal method which were necessary for creating waste flow diagram and evaluating waste eco - efficiency indicator.

3.2.1 3R Waste Ratio

In order to show the potential performance and the environmental benefits of industrial waste circulation, 3R waste ratio (3RWR) was selected as an indicator, which was designed based on the previous literature [21]. 3RWR reflected the ratio between total amount of the 3R materials in ton to total amount of the industrial waste generated from factories in each industrial estate in ton. 3RWR indicator can demonstrate the efficiency of industrial waste management with respect to the reuse, recycle, and recovery activities.

$$3RWR_t = \frac{RW_t}{IDW_t} \qquad \ldots (3.1)$$

From Equation 3.1 $3RWR_t$ is the ratio of reuse, recovery and recycle waste volume in each industrial estate to total industrial waste in industrial estate “t”, RW_t is reuse, recovery and recycle waste volume in industrial estate “t” (ton), and IDW_t is total industrial waste generated from each industrial estate “t”(ton).

3.3 Development of Socio-Eco-efficiency indicator for industrial waste and data analysis

The general definition of eco - efficiency is the relation of environmental impact and value of production by the formula for operational eco - efficiency is: [19]

$$\text{Eco – Efficiency} = \frac{\text{Product or Service Value}}{\text{Environmental Influence}} \quad \dots (3.2)$$

In this study, the eco - efficiency analysis was included social acceptation issues that involve, important, and related with waste management in equation follows.

$$\text{Socio-Eco-Efficiency} = \frac{\text{Product or Service Value}}{\text{Environmental Influence} \times \text{Social Factor}} \quad \dots (3.3)$$

Product or service value is replaced with profit from the difference of the selling price of 3R waste (reuse, recycle, and recovery) and cost of treatment from total disposal waste as landfill and incineration in baht. Environmental influence was replaced with volume of total industrial waste occurred from industrial estate in Map Ta Phut Complex area in ton. Then the value has been multiplied with the social acceptation factor in equation as follow;

$$\text{S.E.E.} = \frac{\text{Income from 3R Waste – Cost of Disposal Waste}}{\text{Total Industrial Waste} \times \text{Social Factor}} \quad \dots (3.4)$$

$$\text{Socio-Eco-Efficiency} = \frac{\sum_{t=1}^{n} IRW_t - \sum_{t=1}^{n} CDW_t}{\sum_{t=1}^{n} IDW \times SF} \quad \ldots (3.5)$$

$$\text{S.E.E.} = \frac{[(P_1 \cdot W_1) + (P_2 \cdot W_2) + \ldots + (P_n \cdot W_n)] - [(C_1 w_1) + (C_2 w_2) + \ldots + (C_n w_n)]}{\sum_{t=1}^{n} IDW \times SF} \quad \ldots (3.6)$$

Where P_w is the selling price of 3R waste in each type including glass, paper, plastics, etc, from Map Ta Phut industrial Complex area in baht. The detail of price was shown in Table 3.1 and the price calculation shown in Equation 3.7

Table 3.1: Average selling price of 3R waste

Type of waste	Selling price (Baht/ton)
Paper	4,475 [a]
Wood	900 [b]
Rubber	89,966.25 [c]
Plastic	9,321.43 [a]
Metal	29,452.29 [a]
Oil	64,999.76 (Baht/1,000 Litre) [d]
Sludge	Priceless
Electronic	12,083.33 [a]
Chemical	Priceless
Waste water	Priceless
Glass	1,004.55 [a]
Other	Priceless

Source: [a] Wongpanit (5/7/2008)

[b] Asia Biomass (18/3/2010)

[c] Nakorn Srithammarat Rubber Market (24/2/2010)

[d] Siam Wattana Oil (9/2/2010)

$$\text{Total selling price} = \sum_{i=1}^{a} \text{Selling price}_{a} \times \sum_{i=1}^{b} \text{3R Waste volume}_{b}\ (\text{ton}) \qquad \ldots (3.7)$$

W_n is 3R waste volume in each type including glass, paper, plastics, etc, from Map Ta Phut industrial Complex area in ton

C_n is cost of treatment from total disposal waste as landfill, incineration, and other in baht per weight unit in ton (Baht/ton). The detail of cost shown in Table 3.2 and cost calculation shown in Equation 3.8

$$\text{Total disposal cost} = \sum_{i=1}^{c} \text{Disposal cost}_{c} \times \sum_{i=1}^{d} \text{Disposal waste volume}_{d}\ (\text{ton}) \qquad \ldots (3.8)$$

Table 3.2: Cost of industrial disposal waste treatment

Treatment Methods	Cost (Baht/ton)
Landfill (Hazardous)	3,800*
Landfill (Non - Hazardous)	1,300*
Incineration (Hazardous)	10,000**
Incineration (Non - Hazardous)	3,500**
Other	Use landfill rate

Source: * Better World Green Public Company Limited (22/03/2010)

** Waste Management Siam Ltd. (WMS) Bang Pu site (22/03/2010)

w_n is industrial waste volume in each treatment methods occurs from industrial estate in Map Ta Phut Complex area in ton

IDW is total industrial waste volume occurs from industrial estate in Map Ta Phut Complex area in ton

SF is Social acceptation factor score derived from the comparison of each scenario for identify the most important issue that can be affect to nearby people.

In the part of social acceptation is determined by establish the different scenario with different percentage of each issues for develop and expand the evaluation for approach to sustainable development by the social acceptation issue that selected were

1.) Social acceptance

1.1) Odor - survey by use a questionnaire with people around the treatment place area and nearby about odor impact level. The criteria shown in Table 3.3

1.2) Noise – survey by use a questionnaire with people around the treatment place area and nearby about noise impact level. The criteria shown in Table 3.3

1.3) Leachate - survey by use a questionnaire with people around the waste treatment place area and nearby about waste water from site of landfill. The criteria shown in Table 3.3

1.4) Distance from the community – survey by use a questionnaire with people around the treatment place area and nearby about the acceptance of distance from the community. The criteria shown in Table 3.3

1.5) Scenery - survey by use a questionnaire with people around the treatment place area and nearby about visual pollution from waste treatment place. The criteria shown in Table 3.3

2.) Management system and Safety

Management system and Safety is survey by use a questionnaire with people around the treatment place area and nearby about management system and feeling for safety with waste treatment place including incineration site and landfill site. The criteria shown in Table 3.3

3.) Operation accident

Operation accident is survey by use a questionnaire with people around the treatment place area and nearby about accident from waste treatment place operation including incineration site and landfill site around the industrial estate in Map Ta Phut Complex area, Rayong province, based on the published document about risk assessment and safety in workplace [22]. The criteria shown in Table 3.3

1.) Illness from operation

The illness from operation is survey by use a questionnaire with people around the treatment place area and nearby opinion about illness symptoms in one year past. The criteria shown in Table 3.3

Table 3.3: Social acceptation criteria

Criteria	Level	Sources
1. Social acceptance		
1.) Odor	1.1) Non	[23]
	1.2) Low	
	1.3) Medium	
	1.4) High	
2.) Noise	2.1) Non	[23]
	2.2) Low	
	2.3) Medium	
	2.4) High	
3.) Leachate	3.1) Non	[24]
	3.2) Low	
	3.3) Medium	
	3.4) High	
4.) Distance from community	4.1) Agree	[24]
	4.2) Disagree	
5.) Scenery	5.1) None	[23]
	5.2) Low	
	5.3) Medium	
	5.4) High	
2. Management system and Safety	2.1 None	[25]
	2.2 Low	
	2.3 Medium	
	2.3 High	

Table 3.3: Social acceptation criteria (cont.)

Criteria	Level	Sources
3. Operation accident	2.1 Not in 10 years	[23]
	2.2 1 time in 10 years	
	2.3 1 time in 5 years	
	2.4 More than 1 time in 1 year	
4. Illness from operation	3.1 No	[26]
	3.2 Yes	

3.3.1 Social acceptation scenarios

From four social acceptation issues, social acceptance, management system and safety, operation accident, and illness from operation, each issue in each scenario is weighted in different percentage multiplied by score of disagreement in each issue as shown in Equation 3.9

$$\text{Social Acceptation Score} = \text{Score of acceptation} \times \text{Weighting volume (\%)} \quad \ldots (3.9)$$

Where Score of acceptation came from percent of nearby people opinion that affected and disagree in each issue as social acceptance, management system and safety, operation accident, and illness from operation

Weighting volume is divided into 6 scenarios with different percentage as shown in Table 3.4

Table 3.4: social acceptation scenarios

Social acceptation issues	Scenarios					
	1	**2**	**3**	**4**	**5**	**6**
Social acceptance	85%	70%	55%	40%	25%	10%
Management system and safety	5%	10%	15%	20%	25%	30%
Operation accident	5%	10%	15%	20%	25%	30%
Illness from operation	5%	10%	15%	20%	25%	30%

CHAPTER IV
RESULTS AND DISCUSSION

From the study, this chapter about the results and discussion of development of Socio-Eco-Efficiency Indicators for Assessment of Industrial Waste from Industrial Estate in Map Ta Phut Complex area, Rayong province, the topic can divided into 3 groups as follow;

4.1 Industrial waste volume and 3R waste ratio

4.2 Industrial waste flow diagram

4.3 Socio-Eco-Efficiency

4.1 Industrial waste volume

From the preliminary industrial waste data over the year 2006 to 2008 form MTPIC area, , which consists of four industrial estates, Map Ta Phut industrial estate (MTPIE), Padang industrial estate (PIE), Hemaraj Eastern industrial estate (HEIE), and Asia industrial estate (AIE), located in Rayong province, eastern of Thailand. The data gathered from the electronic waste management online system, Ministry of Industry, monitoring report, and data available at the Industrial Estate Authority of Thailand. The industrial waste divide into 12 categories including, paper, wood, rubber, plastics, metal, oil, sludge, electronic, chemical, waste water, glass ,and other, can conclude the industrial waste volume as in Table 4.1

MTPIC area is a petrochemical and chemical base industrial area, which comprised of four major operational industrial estates, MTPIE, PIE, HEIE, and AIE (RIL industrial estate is under construction). Table 4.1 and Figure 4.1 illustrated the characterized of industrial waste and Table 4.2 – Table 4.3 illustrated the 3R and disposal waste volume generated from the MTPIC area over the year 2006 to 2008. From Table 4.1, it was found that the total amount of industrial waste generated from the four industrial estates in MTPIC area was 6,978,067.95 ton, accounting for

2,326,022.65 ton per year. MTPIE generated the highest amount of industrial waste compared to other industrial estates was 5,436,788.82 ton, accounting for 1,812,262.94 ton per year and the second was HEIE was 796,139.22 ton, accounting for 265,379.74 ton per year (Figure 4.1).

Table 4.1: Waste composition from industrial estates in Map Ta Phut Industrial Complex area (MTPIC) (2006-2008) (ton)

	MTPIE	PIE	HEIE	AIE	Total	Avr./Yr.
Paper	13,794.00	2,050.00	569.00	1,449.00	17,862.00	5,954.00
Wood	46,543.20	2,770.00	2,970.00	4,320.00	56,603.20	18,867.73
Rubber	637.40	-	510.00	-	1,147.40	382.47
Plastics	197,402.25	12,690.00	10,209.20	7,341.00	227,642.45	75,880.82
Metal	52,055.59	2,910.00	206,559.93	10,629.00	272,154.52	90,718.17
Oil	47,504.90	770.00	5,282.10	1,815.00	55,372.00	18,457.33
Sludge	4,567,431.29	2,700.00	370,987.20	95,451.02	5,036,569.51	1,678,856.50
Electronic	4,185.61	8.42	76.48	165.50	4,436.01	1,478.67
Chemical	84,725.86	6,341.00	40,306.72	39,521.00	170,894.58	56,964.86
WWT.	150,658.80	180.00	67,841.00	33,813.00	252,492.80	84,164.27
Glass	35.20	-	1.00	169.00	205.20	68.40
Other	271,814.72	2,882.65	90,826.59	517,164.32	882,688.28	294,229.43
Total	5,436,788.82	33,302.07	796,139.22	711,837.84	6,978,067.95	2,326,022.65

Table 4.2: 3R waste volume (ton)

Year	MTPIE	PIE	HEIE	AIE	Total
2006	1,946,404.83	7,299.00	104,453.02	33,384.00	2,091,540.85
2007	1,262,407.83	10,934.00	171,142.48	285,769.10	1,730,253.41
2008	1,360,159.30	10,210.00	224,289.82	259,138.40	1,853,797.52
Total	4,568,971.96	28,443.00	499,885.32	578,291.50	5,675,591.78
Avg./Yr..	1,522,990.65	9,481.00	166,628.44	192,763.83	1,891,863.93
SD	369,930.41	1,924.03	60,045.79	138,667.76	183,627.18

Table 4.3: Disposal waste volume (ton)

Year	MTPIE	PIE	HEIE	AIE	Total
2006	137,984.09	1,668.07	110,531.46	37,593.80	287,777.42
2007	398,828.24	1,732.00	64,211.64	72,654.74	537,426.62
2008	331,004.53	1,459.00	121,510.80	23,297.80	477,272.13
Total	867,816.86	4,859.07	296,253.90	133,546.34	1,302,476.17
Avg./Yr..	289,272.29	1,619.69	98,751.30	44,515.45	434,158.72

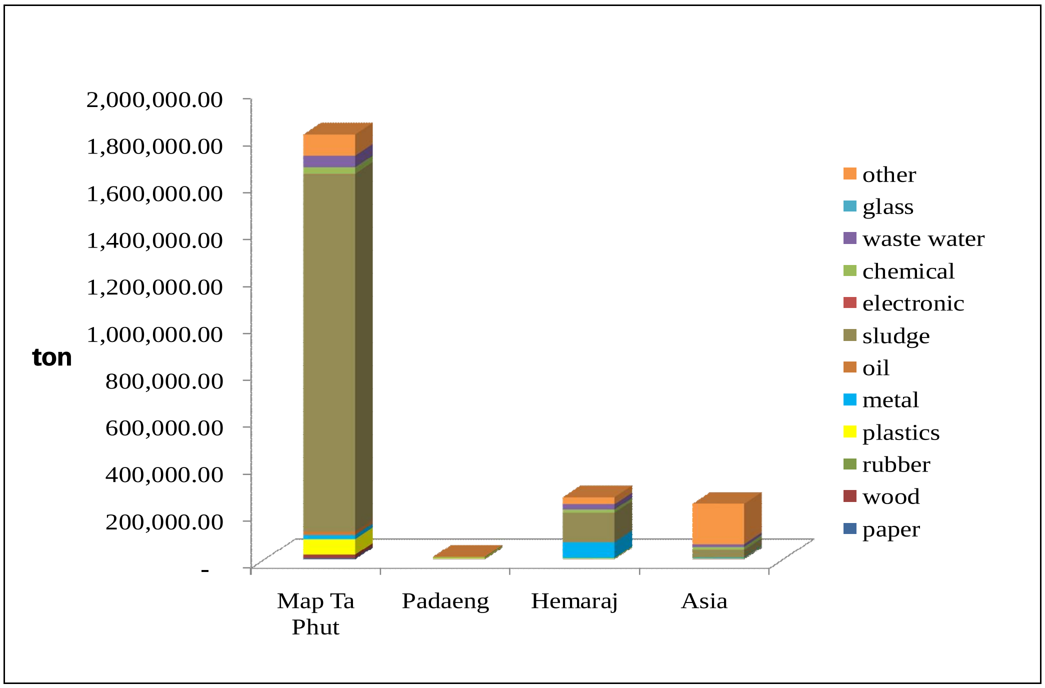

Figure 4.1 Trend of industrial waste from MTPIC average per year in ton

This can be explained by the number of factories located in the MTPIE, which were higher than other industrial estates. By looking at the components of industrial waste, sludge was found to be the highest component, which was 5,037,159.59 ton or 72.18 % of the total amount of industrial waste, accounting for 1,678,856.50 ton per year and the trend decreased over the year 2006 to 2008 about 566,727.23 ton. Following with the next components were waste in other group and metal group, which were 888,258.27 ton or 12.73 % and 272,154.52 ton or 3.90 % and both groups also increase over the year 2006 to 2008 about 286,569.32 ton and 27,961.77 ton respectively, shown in Figure 4.2

When consider the Proportion of industrial waste from MTPIC area between disposal waste and 3R waste, 3R waste proportion was 81.42 % compared to disposal waste. The other treatment method groups such as co–incineration in cement kiln, collect and export, and land reclamation were the highest volume compared to other methods in disposal waste group, shown in Figure 4.3

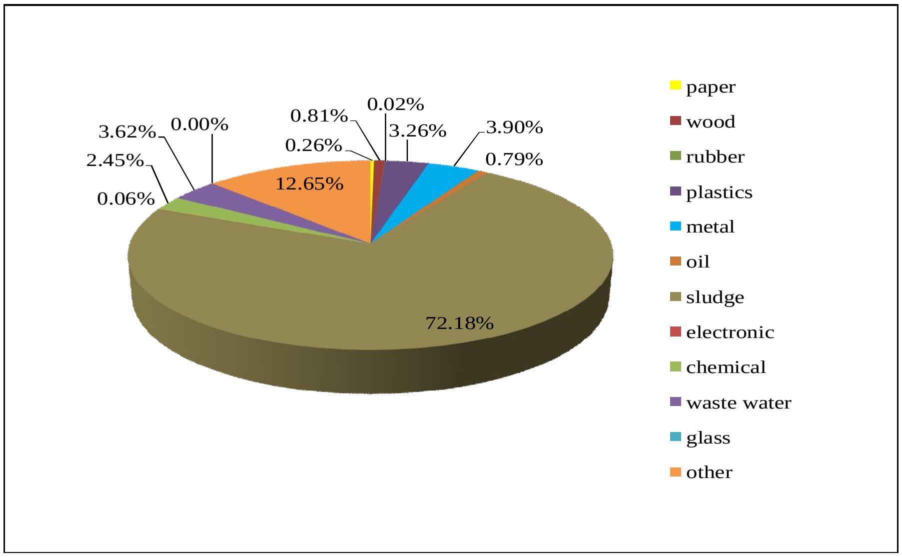

Figure 4.2 Characterization of industrial waste from MTPIC area

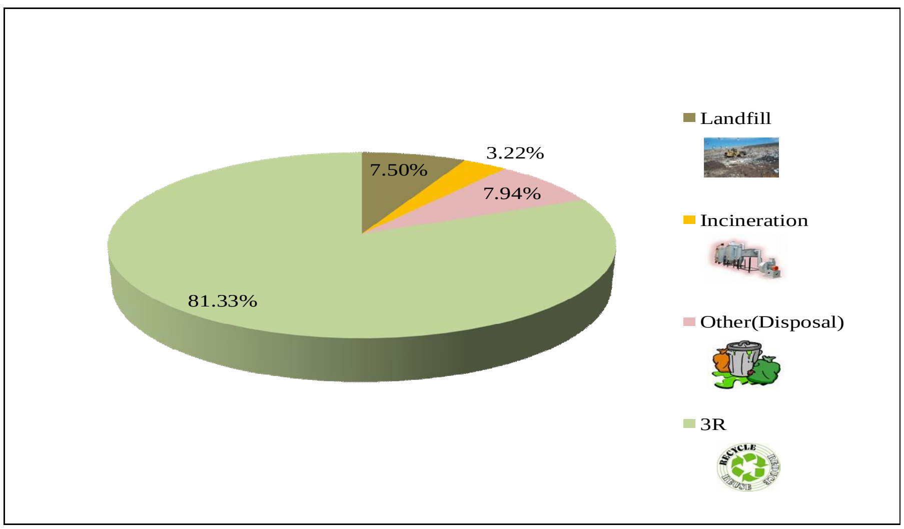

Figure 4.3 Proportion of industrial waste from MTPIC between disposal and 3R waste

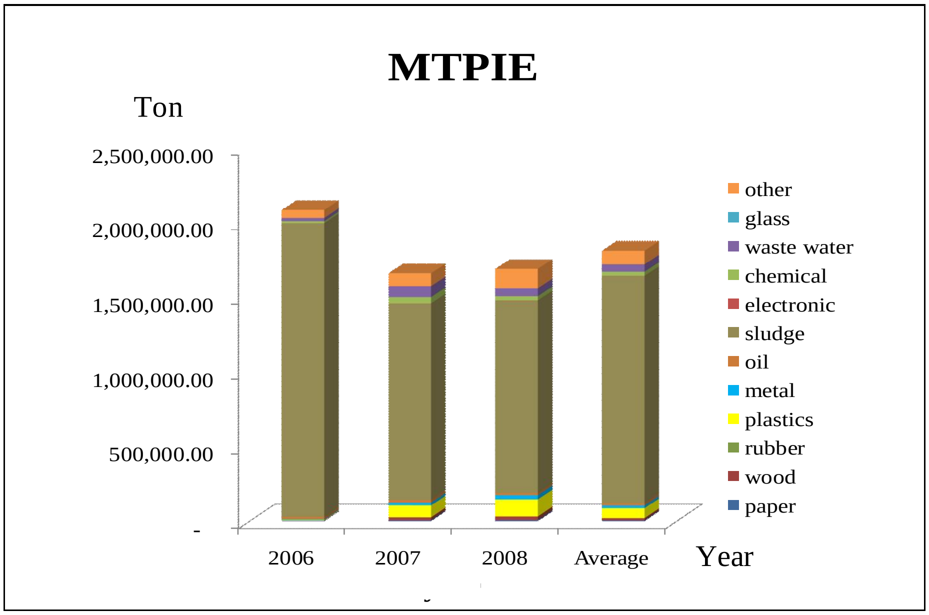

Figure 4.4 Trend of industrial waste from MTPIE

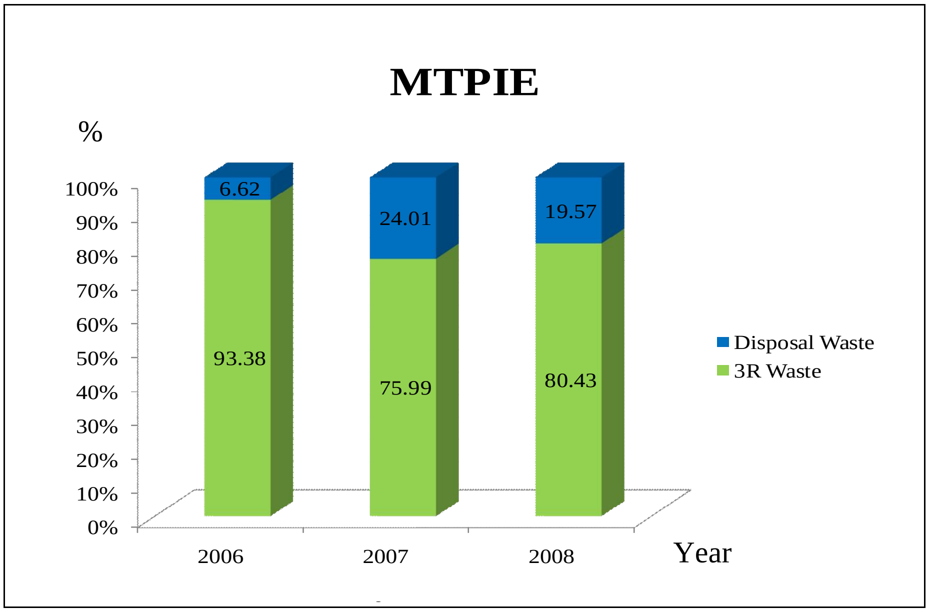

Figure 4.5 Proportion between disposal waste and 3R waste from MTPIE

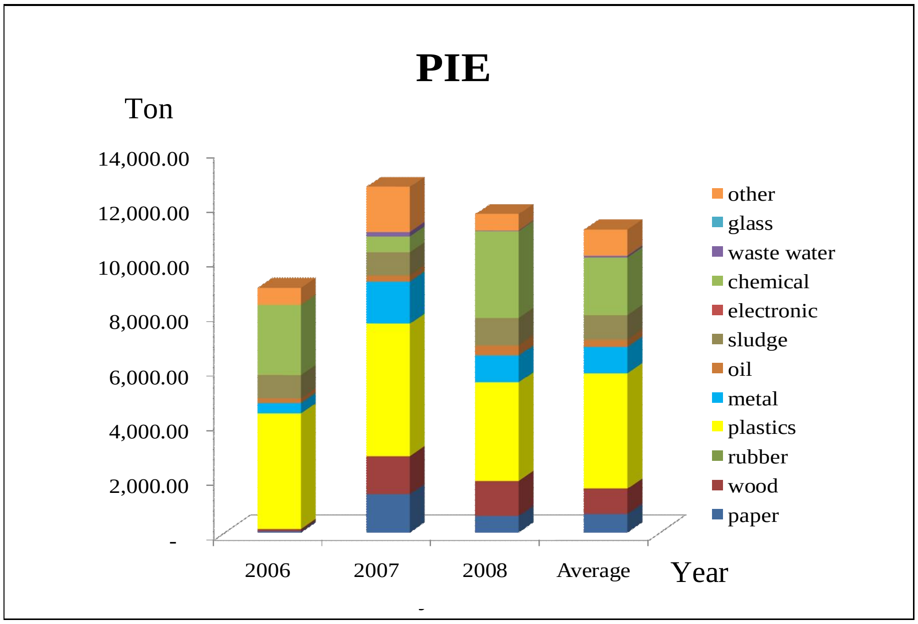

Figure 4.6 Trend of industrial waste from PIE

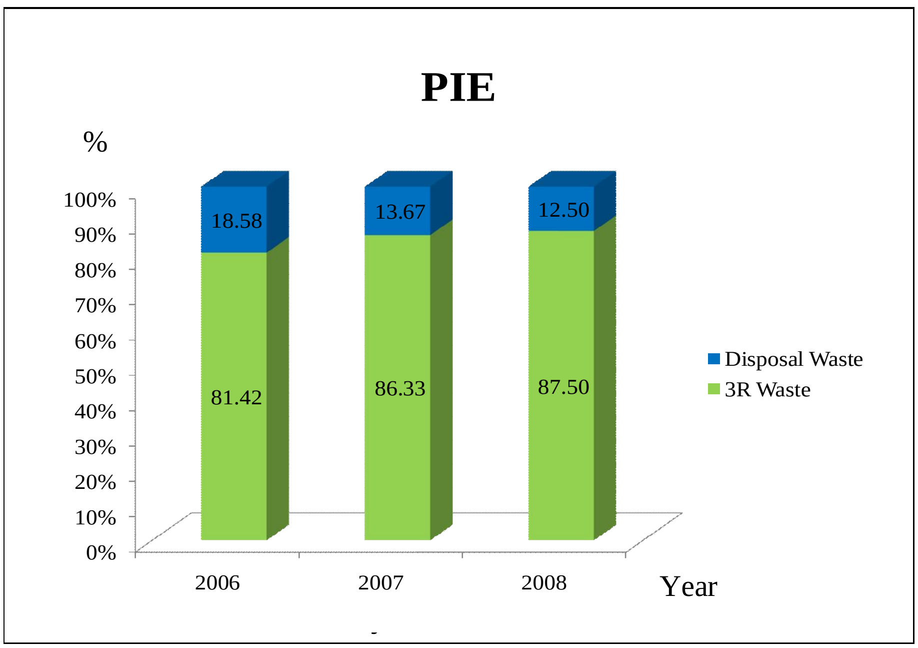

Figure 4.7 Proportion between disposal waste and 3R waste from PIE

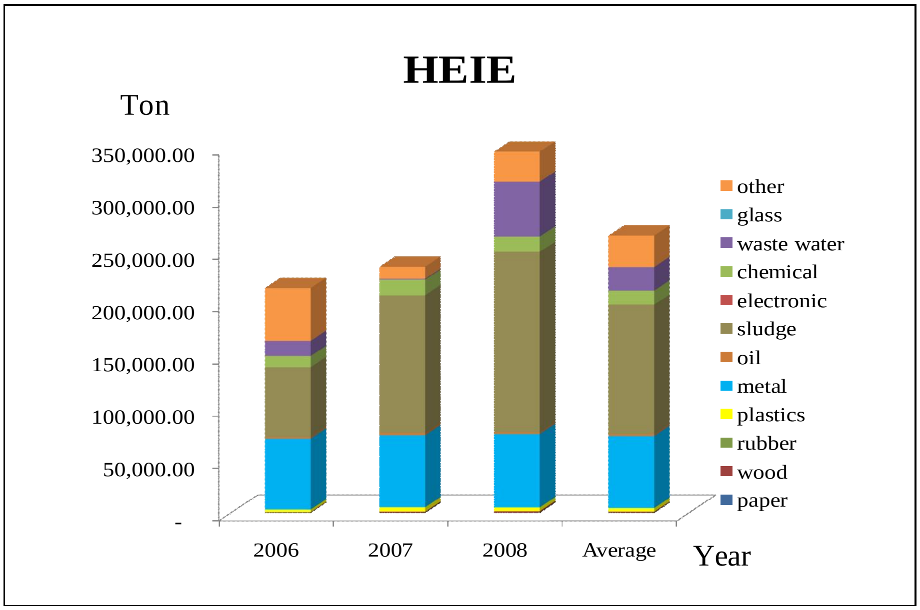

Figure 4.8 Trend of industrial waste from HEIE

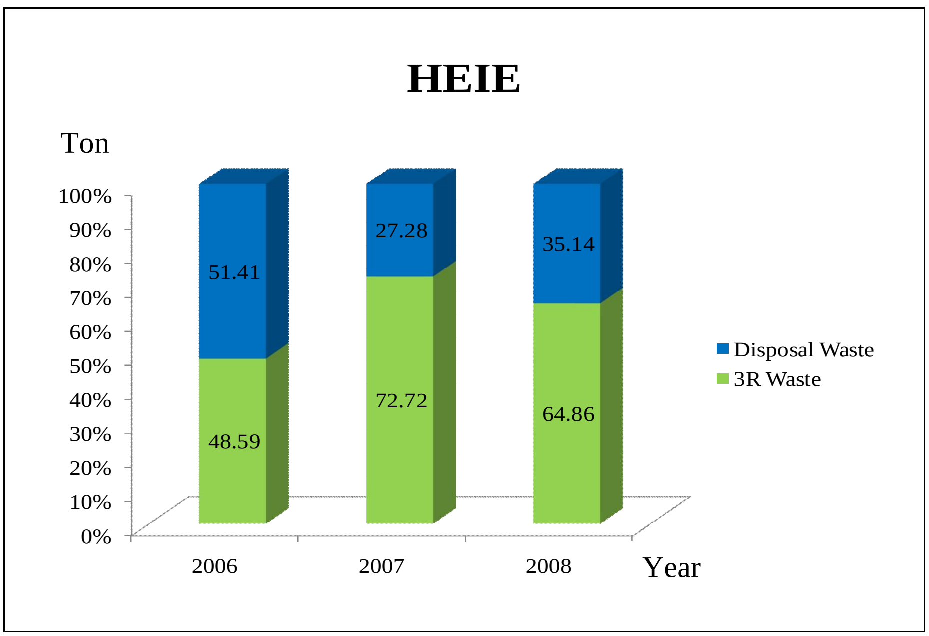

Figure 4.9 Proportion between disposal waste and 3R waste from HEIE

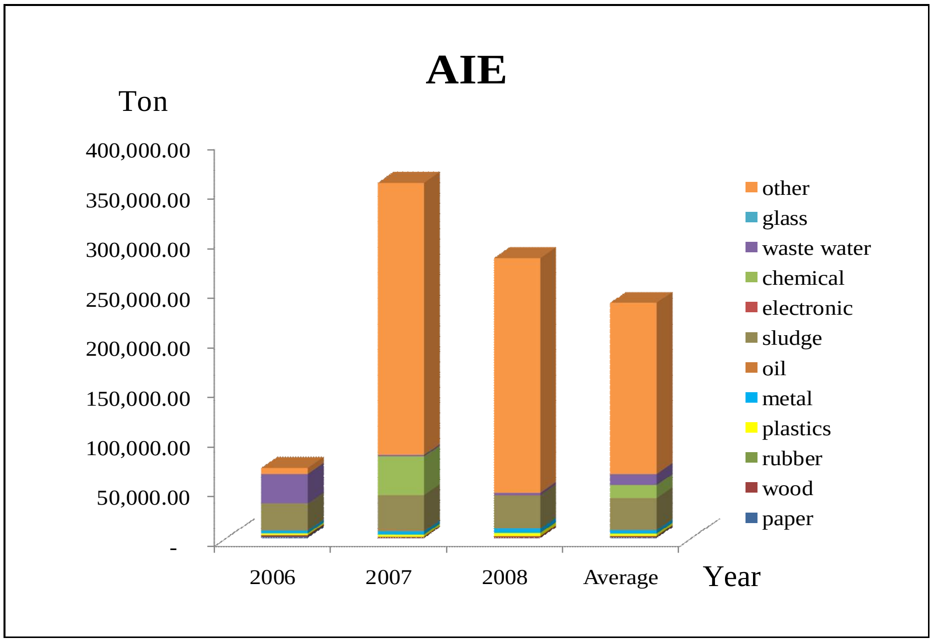

Figure 4.10 Trend of industrial waste from AIE

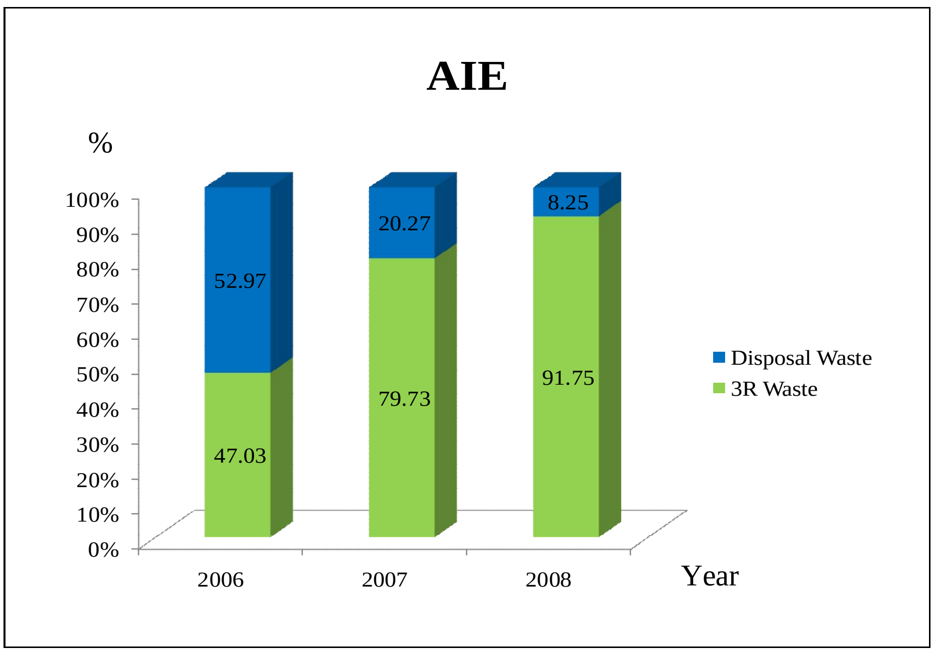

Figure 4.11 Proportion between disposal waste and 3R waste from AIE

In the Figure 4.4 - 4.11 illustrated the characterization of industrial waste and the proportion between disposal waste and 3R waste separated for each industrial estate. It can be seen that the trend of industrial waste generated from the HEIE increased over the year 2006 to 2008. On the other hand, the amount of industrial waste generated from the MTPIE decreased over the year 2006 to 2008.

Sludge was the highest component because Map Ta Phut Industrial Complex is a macro scale petrochemical and chemical industrial area that made a lot of sludge waste such as crude oil that entrapped with the effluents during a production process. The petroleum sludge is attributed to two major factors controlling in its formation, the first is the inorganic residue (sediments, sands, scales and dust) and the second is the precipitates of paraffinic wax, since wax precipitates are sparingly soluble in crude oil, the reason behind wax precipitation is temperature changes [27]

The highest component of industrial waste from HEIE was sludge about 370,987.20 ton accounting for 123,662.40 ton per year and the second was metal about 206,559.93 ton accounting for 68,853.31 ton per year. It can explain that the most of HEIE is consist of petrochemical, metal, chemical and other heavy industry that made a lot of sludge and metal waste and the trend of both waste group also increased over the year 2006 to 2008 about 105,680.20 ton and 2,259.52 ton respectively.

The highest waste component of PIE was plastic about 12,690.00 accounting for 4,230 ton per year and the second was chemical about 6,341.00 ton accounting for 2,113.67 ton per year. But all of plastic waste from PIE is 3R waste that can recycle, reuse and recovery into raw material, use as co-material, reuse container or solvent reclamation and 87.05 % of chemical waste from PIE was 3R waste too.

Other waste such as gypsum, acipin and contaminated waste was the highest waste component from AIE about 517,614.32 ton accounting for 172,388.11 ton per year but 93.59 % of this other waste was 3R waste. The second was sludge about 95,451.02 ton accounting for 31,817.01 ton per year.

In the Figure 4.12 – 4.17 illustrated the proportion between hazardous and non – hazardous waste from industrial estate in Map Ta Phut Complex area. It can be seen that the proportion of 3R non – hazardous waste was the highest when compared with other proportion, the volume shown in Table 4.4 – 4.5

Table 4.4: Hazardous waste value from MTPIC (ton)

Year	MTPIE	PIE	HEIE	AIE	Total
2006	453,548.62	2,176.07	24,947.78	16,094.80	496,767.27
2007	488,738.97	2,736.00	100,151.12	71,466.80	663,092.89
2008	884,294.31	2,739.00	157,783.12	18,283.30	1,063,099.73
Average/Year	608,860.63	2,550.36	94,294.01	35,281.63	740,986.63

Table 4.5: Non - hazardous waste value from MTPIC (ton)

Year	MTPIE	PIE	HEIE	AIE	Total
2006	1,630,840.30	6,791.00	190,036.70	54,883.00	1,882,551.00
2007	1,172,497.10	9,930.00	135,203.00	286,957.04	1,604,587.14
2008	806,869.52	8,930.00	188,017.50	264,152.90	1,267,969.92
Average/Year	1,203,402.31	8,550.33	171,085.73	201,997.65	1,585,036.02

The total hazardous waste volume from MTPIC over the year 2006 to 2008 was increased about 566,332.46 ton or 114.00 % if accounting from year 2006. On the other hand, the total non – hazardous waste volume from MTPIC was decrease over the year 2006 to 2008 about 614,581.08 ton or 32.65 % if accounting from year 2006.

When consider from each industrial estate, MTPIE made the highest hazardous waste volume about 608,860.63 ton per year accounting for 82.17 % of total hazardous waste volume from MTPIC and the trend also increase over the year 2006 to 2008 about 430,745.69 ton or 94.97 % if accounting from year 2006. It show that the MTPIC production trend especially in MTPIE was tend into petrochemical, chemical, or other industry that made a lot of hazardous waste emission and must be controlled especially.

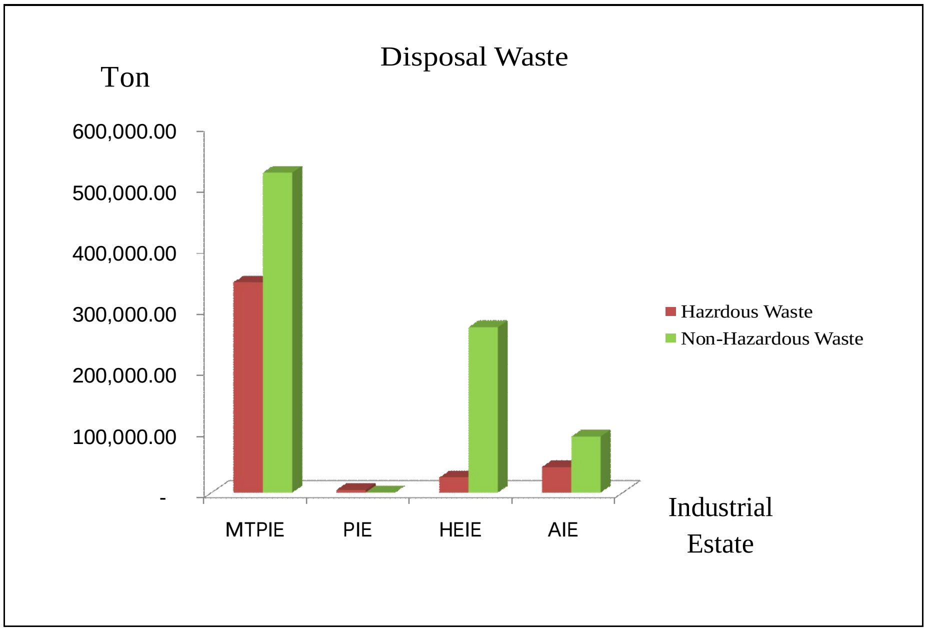

Figure 4.12 The proportion between hazardous and non-hazardous disposal waste from industrial estate in Map Ta Phut Complex area (ton)

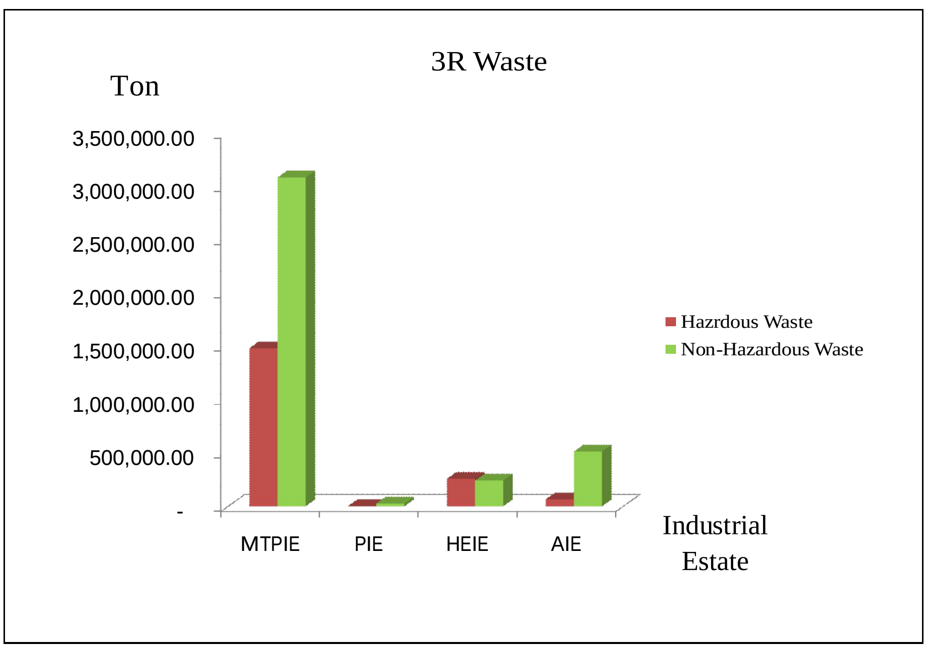

Figure 4.13 The proportion between hazardous and non-hazardous 3R waste from industrial estate in Map Ta Phut Complex area (ton)

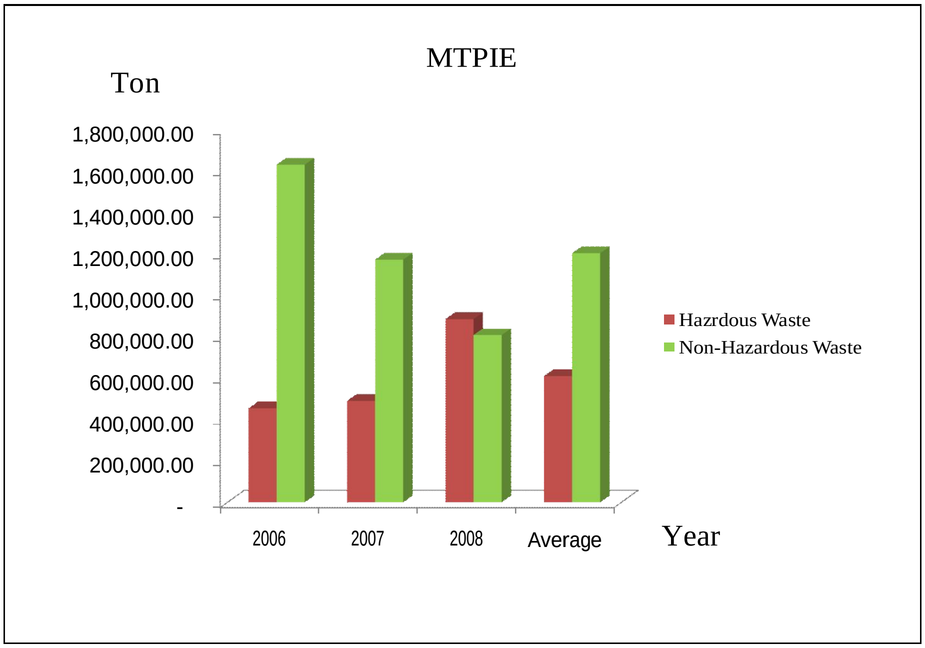

Figure 4.14 The proportion between hazardous and non-hazardous waste from Map Ta Phut industrial estate (ton)

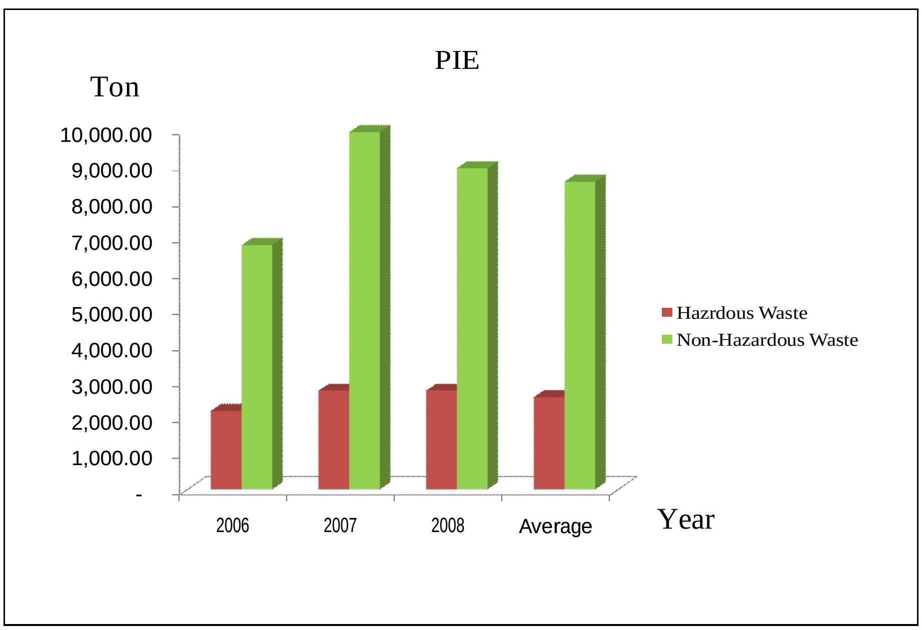

Figure 4.15 The proportion between hazardous and non-hazardous waste from Padaeng industrial estate (ton)

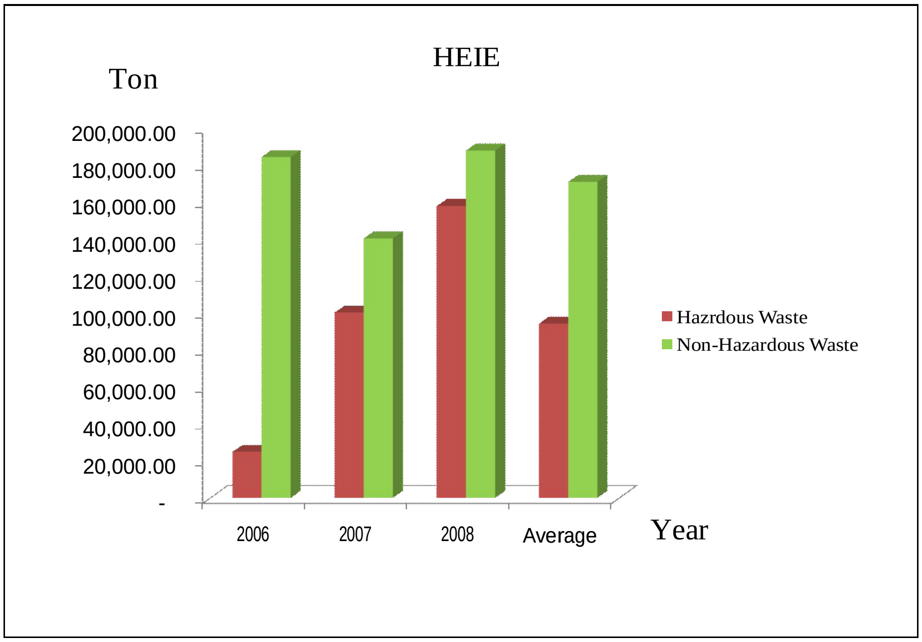

Figure 4.16 The proportion between hazardous and non-hazardous waste from Hemaraj Eastern industrial estate (ton)

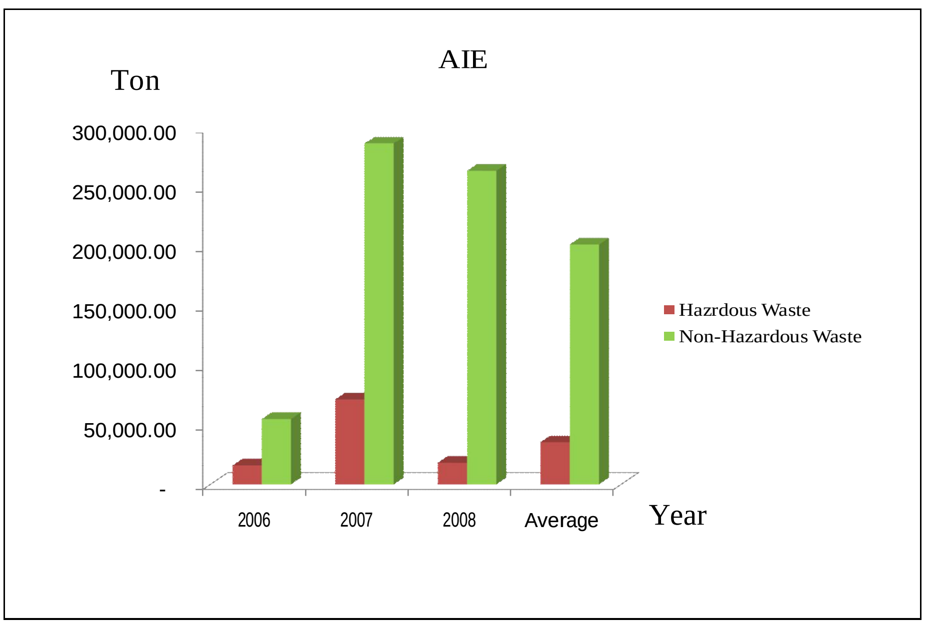

Figure 4.17 The proportion between hazardous and non-hazardous waste from Asia industrial estate (ton)

4.1.1 3R Waste Ratio Result

3R Waste Ratio (3RWR) was the indicator, which reflected the ratio between total amount of 3R materials in ton to total amount of the industrial waste generated from each industrial estate. 3RWR indicator can demonstrate the reuse, recovery and recycle potential of industrial waste. When considered the proportion between 3R and disposal waste volume, the calculation of the ratio between 3R waste to total industrial waste in each industrial estate and each year are shown in Table 4.6 and Table 4.7.In Figure 4.18, and Figure 4.19, it can be seen that PIE showed the highest number of 3RWR, which was 0.854. Following, MTPIE was 0.840, AIE was 0.812 and HEIE was 0.628.

Table 4.6: 3RWR values of average industrial waste per year of industrial estate from MTPIC area

Industrial Estates	3R waste (ton)	Total waste (ton)	3RWR
MTPIE	1,522,990.65	1,812,262.94	0.840
PIE	9,481.00	11,100.69	0.854
HEIE	166,628.44	265,379.74	0.628
AIE	192,763.83	237,279.28	0.812

Table 4.7: 3RWR values of industrial waste per year of industrial estate from MTPIC area

Year	MTPIE	PIE	HEIE	AIE
2006	0.9338	0.8140	0.4859	0.4703
2007	0.7599	0.8633	0.7272	0.7973
2008	0.8043	0.8750	0.6486	0.9175

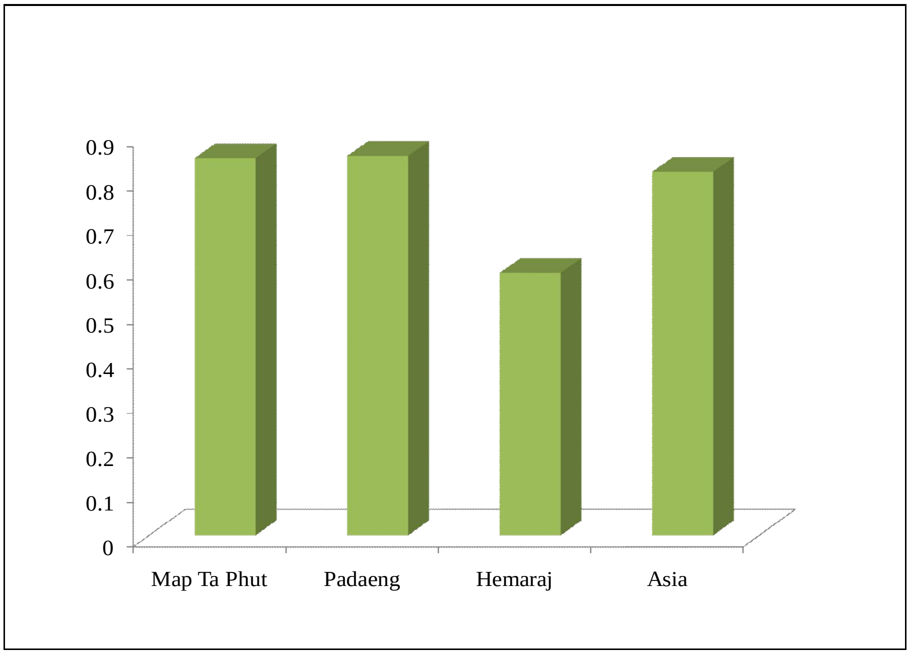

Figure 4.18 3RWR chart of average industrial waste per year of industrial estate from MTPIC area

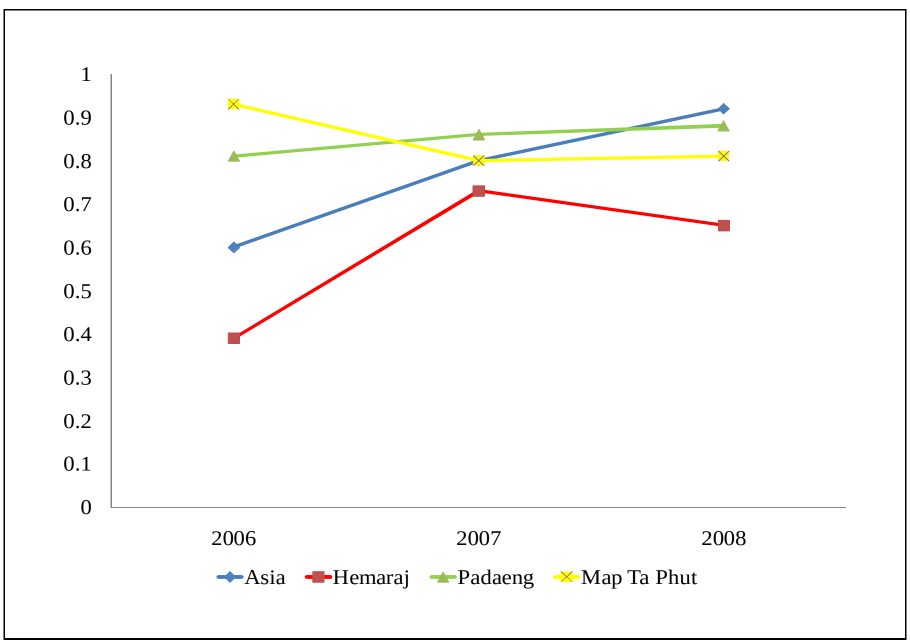

Figure 4.19 3RWR trend of each industrial estate in MTPIC area shows in 3 years

4.2 Industrial waste flow diagram

The waste flow diagram is important and necessary that can be made preliminary waste data more clearly characterization and easy to manage. In this study, waste flow diagram was distinguish the flow of industrial waste into 2 way as 3R waste, divided into 12 categories based on waste type, and disposal waste, divided into 3 categories based on waste treatment methods including landfill, incineration, and other. The results shown in Figure 4.20

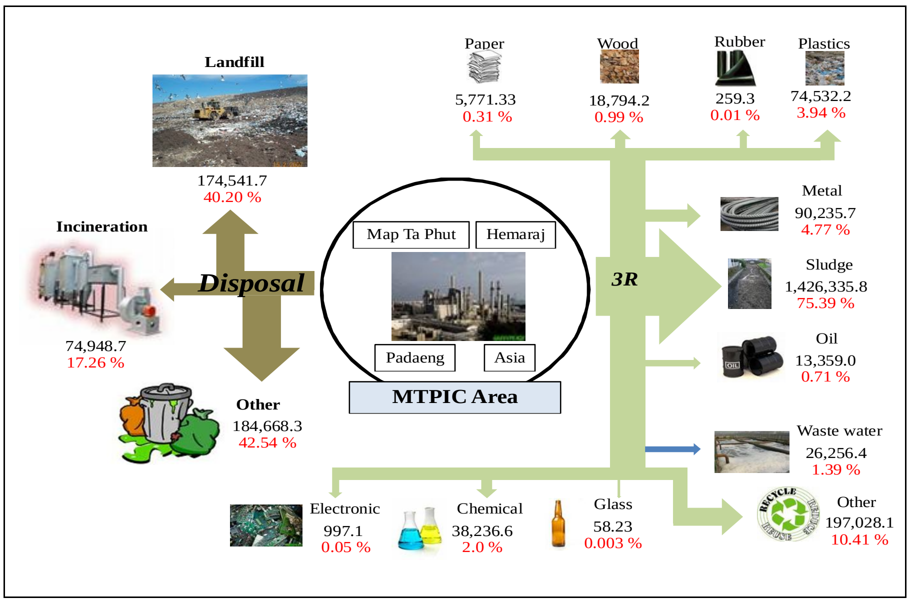

Figure 4.20 Waste flow diagram of industrial waste from Map Ta Phut Industrial Complex (MTPIC) area (ton per year)

From Figure 4.20, the total 3R waste volume is 5,675,591.78 ton or 81.33 % accounting for 1,891,863.93 ton per year. Disposal waste volume is 1,302,476.17 ton or 18.67 % compared to disposal waste, accounting for 434,158.72 ton per year. Disposal waste from MTPIC area was treated by other methods as co–incineration in cement kiln, collect and export, and land reclamation, which was 554,004.91 ton, accounting for 184,668.30 ton per year or 42.54 % compared to other treatment methods. Industrial waste treated by landfill was 523,625.14 ton accounting for 174,541.71 ton per year, or 40.20% compared to other treatment methods and industrial disposal waste treated by incineration was 224,846.12 ton, accounting for 74,948.71 ton per year or 17.26 % compared to other treatment methods.

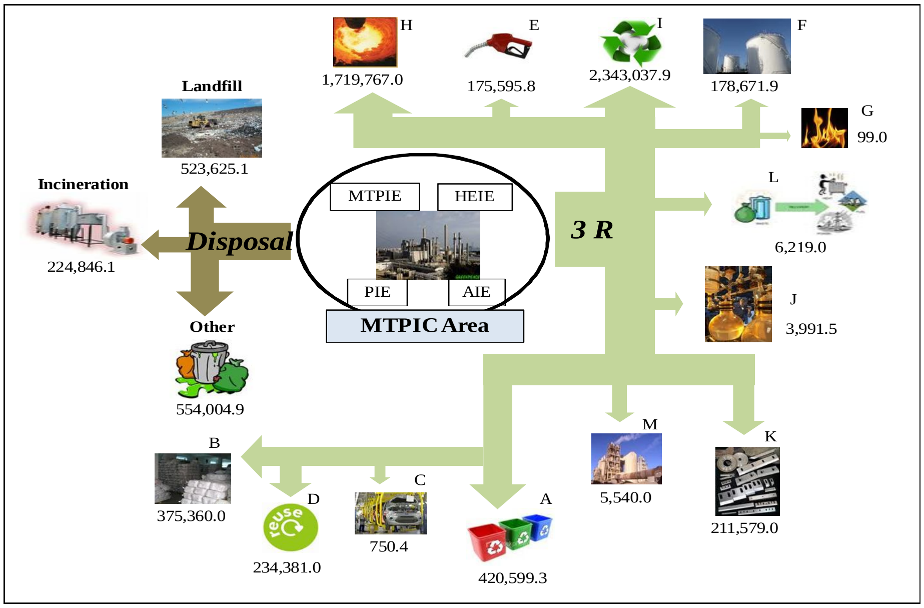

Figure 4.21 Waste flow diagram of industrial waste treatment methods from Map Ta Phut Industrial Complex (MTPIC) area (ton)

From Figure 4.21 A is Sorting for selling

B is Use as raw material substitution

C is Reuse container; to be refilled

D is Other reuse methods

E is Use as fuel substitution or burn for energy recovery

F is Fuel blending

G is Burn for energy recovery

H is Use as co-material in cement kiln or rotary kiln

I is Other recycle methods

J is Solvent reclamation/regeneration

K is Reclamation/regeneration of metal and metal compounds

L is Other recovery unlisted materials

M is Co-incineration in cement kiln

Figure 4.21 shows the treatment methods of industrial waste from MTPIC. The highest volume of 3R waste from MTPIC was treated other recycle method that mostly consists of paper, plastic, metal, used acid, used solvent and sludge waste. The other recycle method may be turn waste paper, scrap paper, metal or scrap metal into a usable product or new goods. The second was use as co-material in cement kiln or rotary kiln that mostly consists of ash, sand, dust and scale and the third was sorting for selling that mostly consists of paper, plastic, metal and wood.

This result shows that waste of industrial waste generated from MTPIC could be recyclable. For example, the sludge derived from heavy oil filtering was recycled by mixing with pyrolysis residues for use as a solid fuel. Almost all the waste plastic, except for the foreign material and water, is being reclaimed and recycled by the research in 2006 shown the recycling rate that excluding the water was reached to 96%. [28]

4.3 Socio-Eco-Efficiency

The total 3 years income from 3R waste in MTPIC area (calculated by following the methodology in section "Development of Socio-Eco-efficiency indicator for industrial waste and data analysis" in Chapter 3 was about 10,737,524,101.45 baht or 3,579,174,700.48 baht per year as shown in Table 4.8 and Table 4.9. Metal was found as the 3R waste that made the highest 3 years income because a price per unit of each type of metal including copper, aluminum, stainless steel or other metal scraps are expensive when compared with other waste. The proportion between income from 3R waste and cost of disposal shown in Figure 4.22 – 4.27

Table 4.8: Income from 3R waste (baht)

Year	MTPIE	PIE	HEIE	AIE	Total
2006	297,476,504.8	53,102,964.0	2,068,923,889.5	115,396,703.8	2,534,900,062.1
2007	1,469,403,340.6	100,537,654.1	2,088,441,316.9	123,655,654.3	3,782,037,965.9
2008	2,081,490,729.1	70,586,910.5	2,112,249,849.5	156,258,584.4	4,420,586,073.5
Total	3,848,370,574.5	224,227,528.6	6,269,615,055.8	395,310,942.6	10,737,524,101.5
Avg.	1,282,790,191.5	74,742,509.5	2,089,871,685.3	131,770,314.2	3,579,174,700.5

Table 4.9: Cost of disposal waste (baht)

Year	MTPIE	PIE	HEIE	AIE	Total
2006	633,069,584.0	9,460,810.0	259,671,522.0	57,239,080.0	959,440,996.0
2007	1,332,701,522.0	8,730,200.0	135,694,656.0	185,206,032.0	1,662,332,410.0
2008	940,216,733.0	5,424,480.0	277,407,398.0	40,745,780.0	1,263,794,391.0
Total	2,905,987,839.0	23,615,490.0	672,773,576.0	283,190,892.0	3,885,567,797.0
Avg.	968,662,613.0	7,871,830.0	224,257,858.7	94,396,964.0	1,295,189,265.7

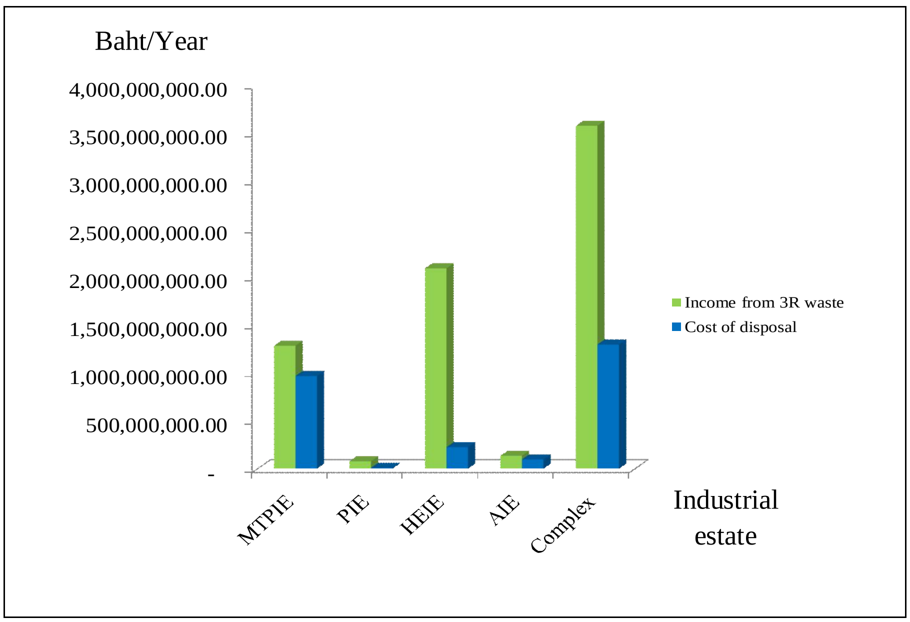

Figure 4.22 Proportion between income from 3R waste and cost of disposal waste in MTPIC

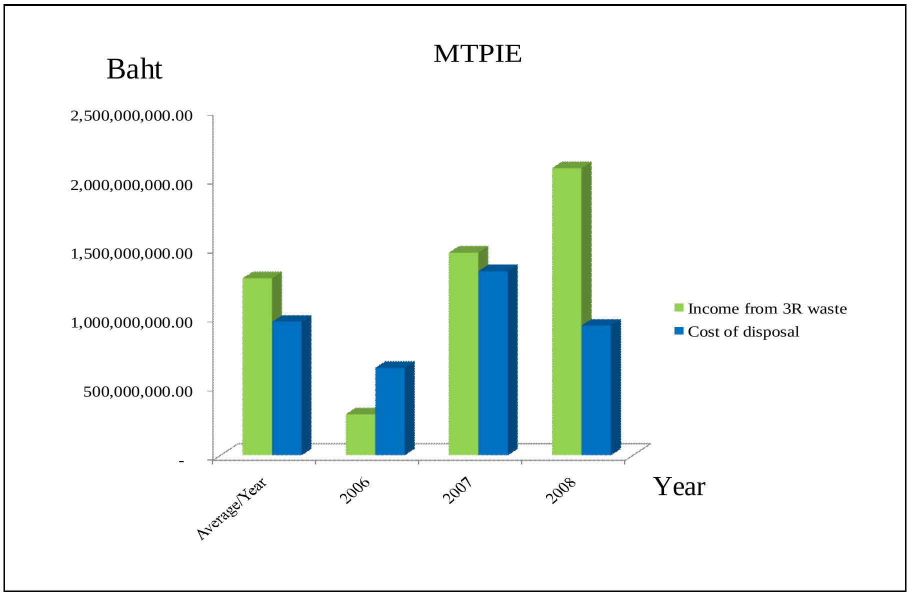

Figure 4.23 Proportion between income from 3R waste and cost of disposal from Map Ta Phut industrial estate

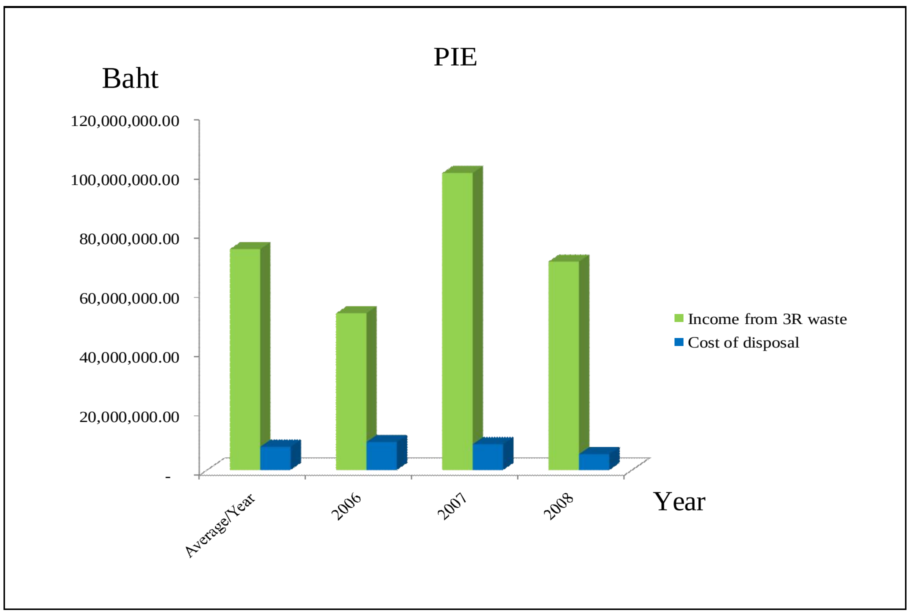

Figure 4.24 Proportion between income from 3R waste and cost of disposal from Padaeng industrial estate

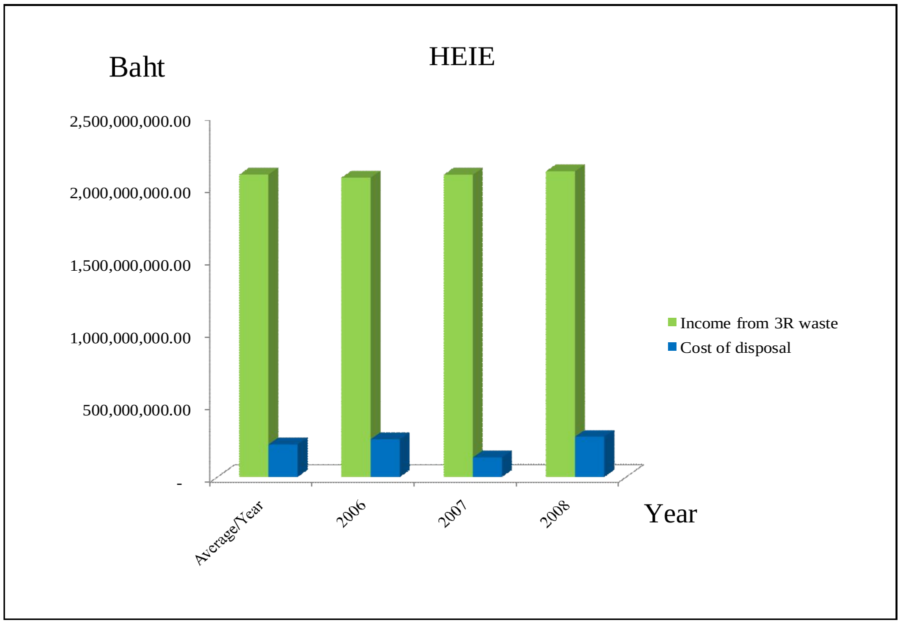

Figure 4.25 Proportion between income from 3R waste and cost of disposal from Hemaraj Eastern industrial estate

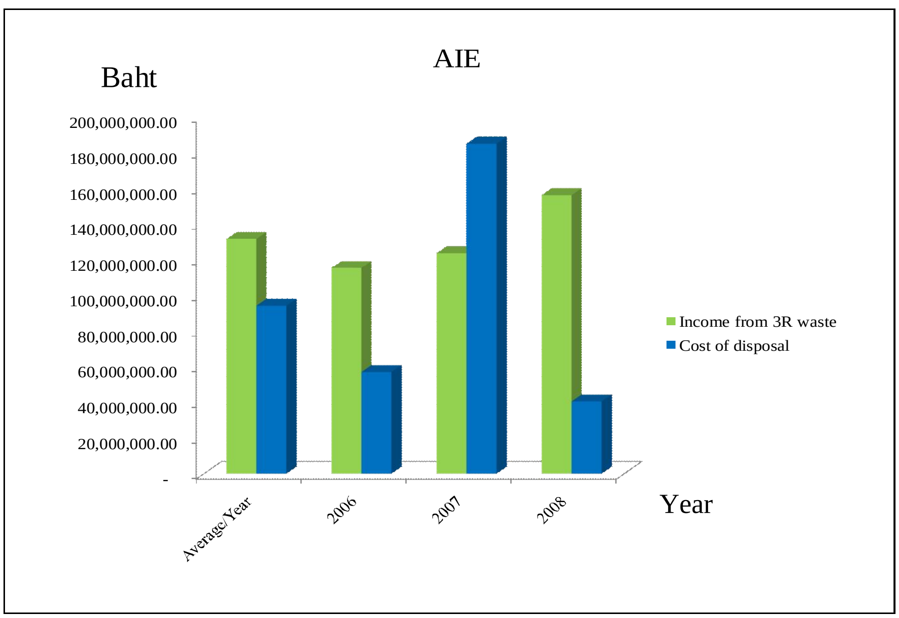

Figure 4.26 Proportion between income from 3R waste and cost of disposal from Asia industrial estate

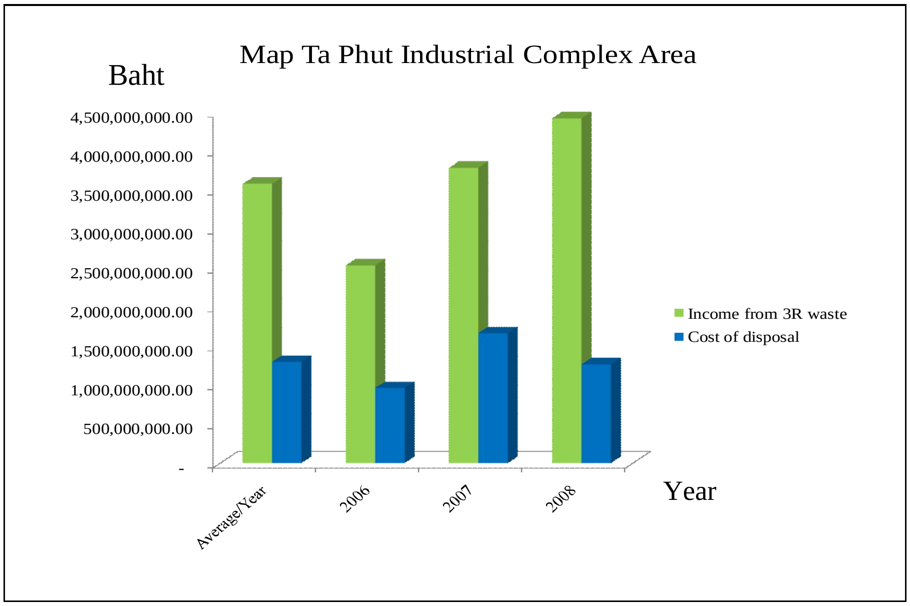

Figure 4.27 Proportion between income from 3R waste and cost of disposal from MTPIC

The total 3 years cost of disposal waste from industrial estates in MTPIC was about 3,885,567,797.0 baht or 1,295,189,265.7 baht per year and the treatment method that made the highest cost was incineration.

4.3.2 Socio-Eco-efficiency

Eco-efficiency is the relation of environmental impact and value of production as follow equation

$$\text{Eco – Efficiency} = \frac{\text{Product or Service Value}}{\text{Environmental Influence}} \quad \ldots(4.1)$$

If consider in two dimensions except the social dimension, the highest eco-efficiency was HEIE as 7,029.98 by the trend of 3 years was decrease. Although the total industrial waste volume from HEIE was increased every year, but the profit from waste selling when minus with disposal cost also high then the eco-efficiency result was still high too. The second of eco-efficiency value was PIE as 6,024.01 and MTPIE were the third as 173.33 because profit from 3R selling in year 2006 was less than cost of waste treatment about 633,069,584.0 baht. The total waste volume was highest when compared to other year and it was much of a muchness in year 2007 and 2008. The result shows in Table 4.10 and the trend of Eco-efficiency are shown in Figure 4.28 – 4.32

Table 4.10: Eco-efficiency of each industrial estate in MTPIC area

Year	MTPIE	PIE	HEIE	AIE	Total
2006	- 161.00	4,866.94	8,415.73	819.38	662.15
2007	82.29	7,248.34	8,297.06	-171.73	934.75
2008	674.85	5,584.23	5,306.07	408.99	1,354.22
Total	173.33	6,024.01	7,029.98	157.51	981.93

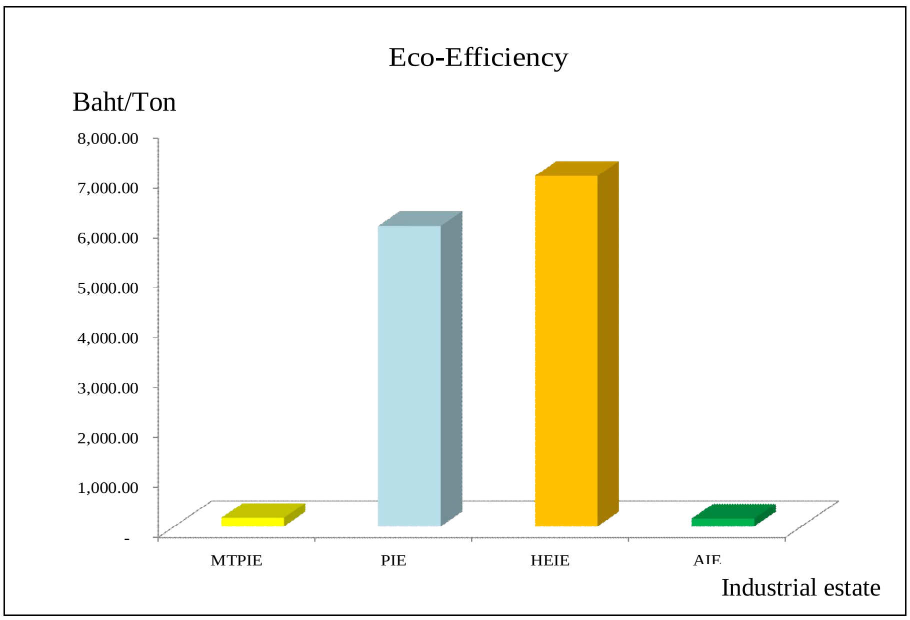

Figure 4.28 Eco-efficiency of industrial estate in Map Ta Phut Area

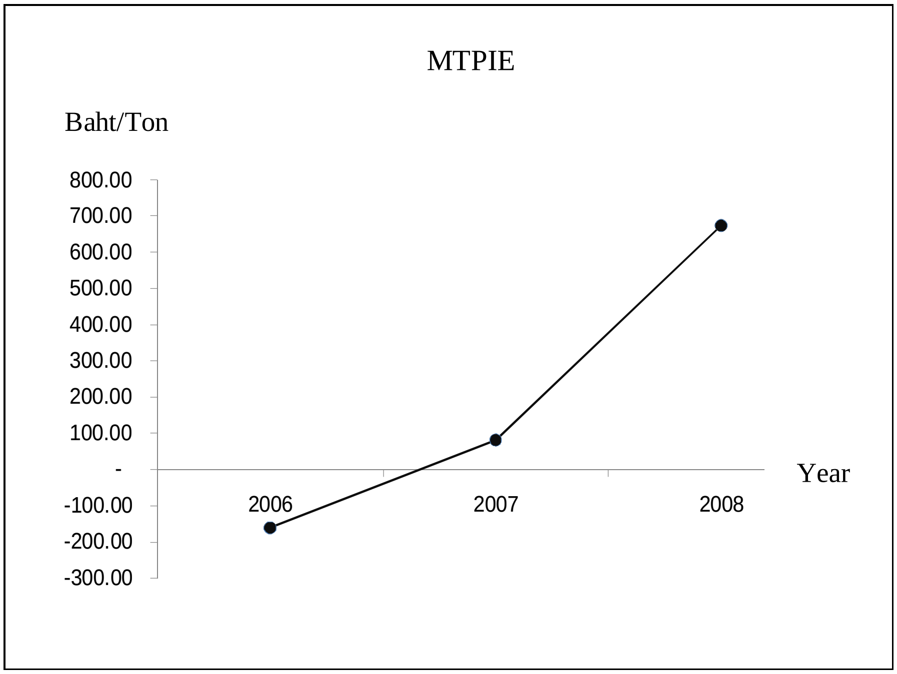

Figure 4.29 Eco-efficiency of Map Ta Phut industrial estate

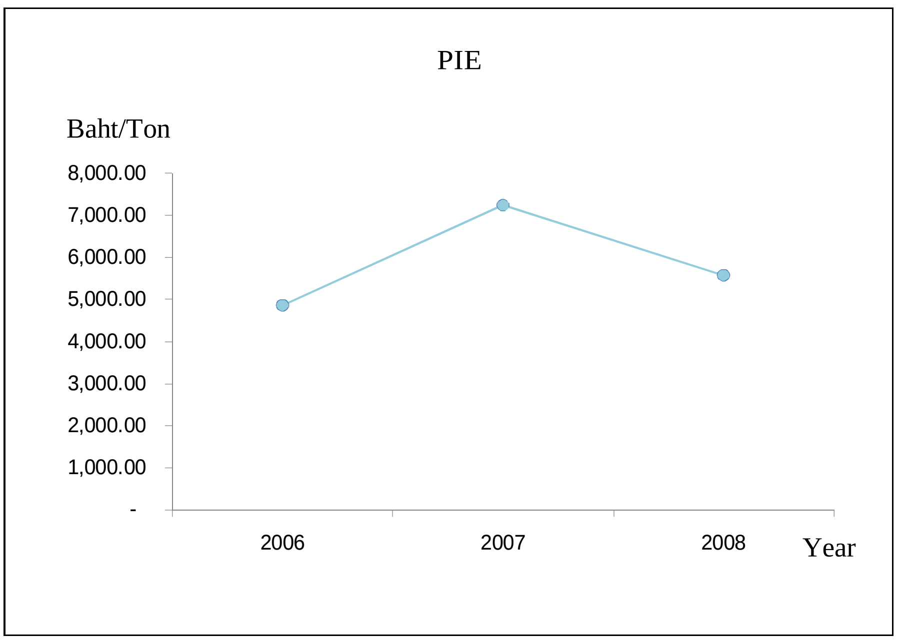

Figure 4.30 Eco-efficiency of Padaeng industrial estate

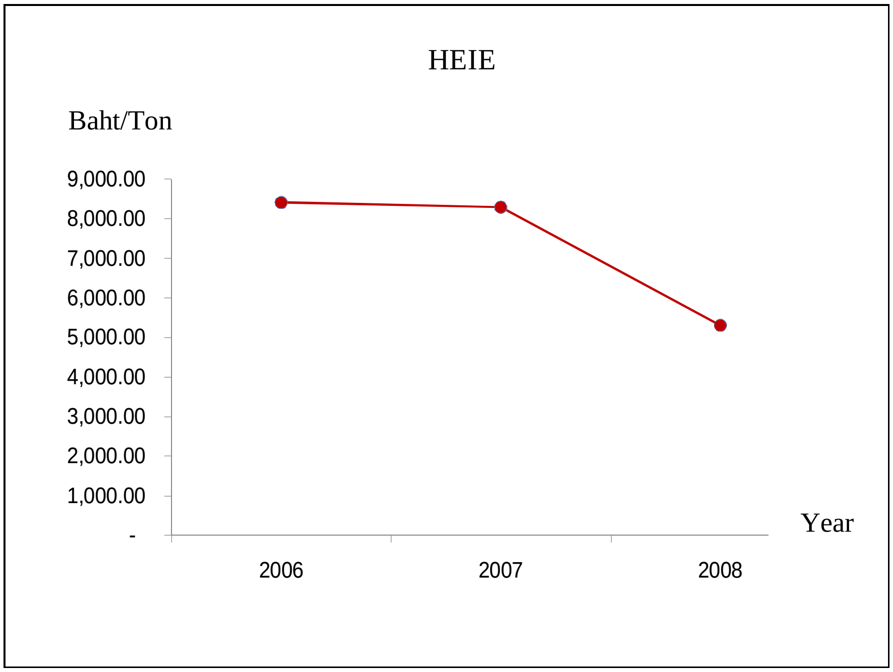

Figure 4.31 Eco-efficiency of Hemaraj Eastern industrial estate

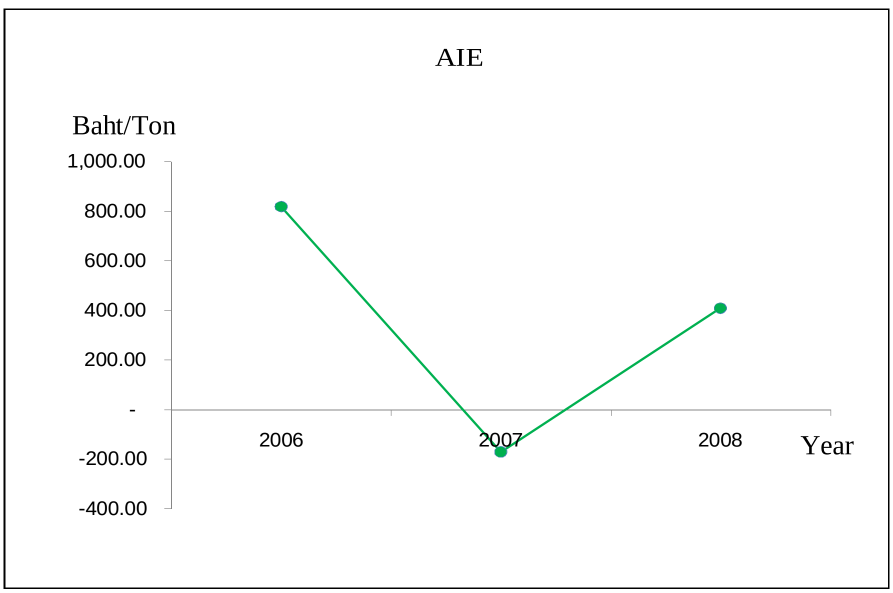

Figure 4.32 Eco-efficiency of Asia industrial estate

Equation 4.2, showed the calculation of three dimensions as economic, environment, and social. The economic dimension is a numerator of the equation if it high, it showed that the profit from 3R waste was high too. In the part of denominator, the environmental dimension is the total industrial waste volume from MTPIC area multiply by social dimension that is social acceptation opinion of nearby people around waste treatment place of the MTPIC area. In this study, the social acceptance value is a percent of people that affected and disagreed in each issue. It means that the industrial estate that high socio-eco-efficiency value is the industrial estate that have the most balance of economic, environment and social potential and efficiency.

$$\text{Socio-Eco-Efficiency} = \frac{\sum_{t=1}^{n} IRW_t - \sum_{t=1}^{n} CDW_t}{\sum_{t=1}^{n} IDW \times SF} \quad \ldots(4.2)$$

The social acceptation score came from percentage of nearby people opinion that affected and disagree in each issue as social acceptance, management system and safety, operation accident and illness from operation from questionnaire, the results are shown in table 4.11. The management system and safety issue has the most percent of disagreement, the details and the questionnaire showed in APPENDIX B.

Table 4.11: Percentage of social acceptation issues

Social acceptation issues	**Percentage**
Social acceptance	**43.93**
- Odor	*77.72*
- Noise	*11.14*
- Leachate	*12.41*
- Distance from community	*75.19*
- Scenery	*43.80*
Management system and safety	**74.43**
Operation accident	**15.44**
Illness from operation	**30.78**

From the different weighting value of each social acceptation issues in each scenario, the score was calculated by multiply with various weighting percentage as shown in Table 3.4, sub social acceptance issues was weighting by 20% equally, the results shown in Table 4.12.

Table 4.12: Social acceptation score

Social acceptance issues	**Scenarios**					
	1	**2**	**3**	**4**	**5**	**6**
Social acceptance	37.37	30.77	24.18	17.58	10.99	4.40
Management system and safety	3.72	7.44	11.16	14.89	18.61	22.33
Operation accident	0.77	1.54	2.32	3.09	3.86	4.63
Illness from operation	1.54	3.08	4.62	6.16	7.70	9.23
Total	43.40	42.83	42.28	41.72	41.16	40.59

When analyze the relation of data by using F-test analysis, all relation value were not significantly ($p < 0.05$) at a 95 % confidence level, as shown in Table 4.13 if null hypothesis (H_0) is the variation of social acceptation weighting score was not affect to social acceptation value changes.

Table 4.13: F-test analysis results

Scenarios	**1**	**2**	**3**	**4**	**5**	**6**
1	-	-	-	-	-	-
2	0.6749	-	-	-	-	-
3	0.3578	0.6052	-	-	-	-
4	0.1561	0.2950	0.5786	-	-	-
5	0.1214	0.2350	0.4801	0.8760	-	-
6	0.2531	0.4514	0.8070	0.7529	0.6392	-

From Table 4.13, it showed that all weighting score scenarios were not significantly different then a weighting score in all issue was equally as 25% in scenario 5 and can calculate the socio-eco-efficiency as shown in Table 4.14 and Table 4.15 and the socio-eco-efficiency can be calculated as Equation 4.2 as follows,

$$\text{S.E.E. (MTPIE)} = \frac{314,127,578.5}{1,812,262.9 \times 41.16} = 4.21$$

$$\text{S.E.E. (PIE)} = \frac{66,870,679.5}{11,100.7 \times 41.16} = 146.36$$

$$\text{S.E.E. (HEIE)} = \frac{1,865,613,826}{265,379 \times 41.16} = 170.80$$

$$\text{S.E.E. (AIE)} = \frac{37,373,350.2}{237,279.3 \times 41.16} = 3.83$$

Table 4.14: Socio-eco-efficiency result

	MTPIE	PIE	HEIE	AIE
Profit from waste (baht)	314,127,578.5	66,870,679.5	1,865,613,826.6	37,373,350.2
Total waste (ton)	1,812,262.9	11,100.7	265,379.7	237,279.3
Social acceptation score	41.16	41.16	41.16	41.16
Socio-eco-efficiency	4.21	146.36	170.80	3.83

Table 4.15 Socio-eco-efficiency result in each year

	MTPIE	PIE	HEIE	AIE	MTPIC
2006	- 3.91	118.24	204.46	19.91	16.09
2007	2.00	176.10	201.58	- 4.17	22.71
2008	16.40	135.67	128.91	9.94	32.90
Total	4.21	146.36	170.80	3.83	23.86

From this result, the highest socio-eco-efficiency was also HEIE about 170.80 and the second was PIE and the third was MTPIE same as the eco-efficiency result and the trend of socio-eco-efficiency of MTPIC in year 2007 was increase about 41.14 % when compared with year 2006. The trend of year 2008 was increase about 104.48 % when compared with year 2006 and 44.87 % when compared with year 2007. In this research, it can be seen that, the important dimension that have an influence with socio-eco-efficiency result is economic and environmental. However, social dimension will be important and can specify the socio-eco-efficiency value if it has an individual score in each place.

CHAPTER V
CONCLUSION AND RECOMMENDATIONS

This study presents the development of eco-efficiency indicators based on the ideas and methods of the eco-efficiency analysis that include an assessment of the social dimension. In this study, industrial estate in MTPIC were used to be a study area by using the 3 years available industrial waste data (2006 – 2008). Industrial waste generated from MTPIC was categorize into 3R waste including reuse, recycle, recovery and disposal waste with creating the flow diagram of industrial waste, analyzing the 3R waste ratio and Socio-Eco-efficiency.

5.1 Industrial waste volume and 3R waste ratio

The industrial waste volume was divided into 12 groups including hazardous and non – hazardous waste. Sludge was found to be the highest component, which was 72.18 % of total waste. When consider the part of hazardous waste, sludge also found to be the highest component (81.84 % of total amount of hazardous waste), which consists of dust, wastewater sludge, activated sludge, ash and contaminated sludge etc., Most disposal sludge was sent to treated by landfill. Most of 3R sludge were use to be land reclamation. However, incineration is prohibitive in terms of cost and still requires the disposal of ash containing potentially hazardous substances in high concentrations. Although there are some efforts to reduce and recover the waste, disposal in landfills is still the most common method for waste disposal and the waste management systems require professional management, supported by an appropriate legislation and policies.

When consider the 3R waste ratio, PIE showed the highest 3R waste ratio about 0.854, PIE could be illustrated as the highest potential to become as an eco-industrial estate, which defines for the close loop material model that using for industrial estate management and in industrialized countries. It has been found that economic aspects are likely to impact on recycling rates. However, a waste database is an essential tool that needs to be developed as grouping or categorize for more easy and efficient data using.

5.2 Waste Flow Diagram

The Industrial waste flow diagram was created by using the gathered data to categorize the type of waste for a convenience of management. It divided waste into 2 categories as disposal waste and 3R waste. 3R waste was found to be the higher proportion when compared with disposal waste as 81.33 % of total waste.

In the macro scale as industrial estate complex, the part of input data in Material Flow Analysis was difficult to gather data as raw material or input energy because a various and a lot of complex data. In the future, waste in the other group of both disposal and 3R waste need more categorize for the effective management planning.

5.3 Socio-eco-efficiency evaluation

Because of the limitation of gathered data, this study can be use only 3 years data with 4 industrial estate as Map Ta Phut industrial estate, Padaeng industrial estate, Hemaraj industrial estate and Asia industrial estate because the data that older than 3 years was not available and RIL industrial estate data is under construction and Map Ta Phut Seaport was not enough information.

The economic aspects are represented in an overall cost calculation. The calculation of economic dimension may be error from the truth because it cannot find the previous selling price of 3R waste. Selling price in year 2008 and 2010 were used for calculation. Disposal cost used standard price of year 2010 from individual company that except the fuel cost, tax or other fee.

From the questionnaire, it can be concluded that the number of disagreed people about distance from waste treatment place and nearby people house issues was 67.09 % from 395 household. 22.28 % had no odor affected. However, noise, leachate, transportation and scenery problems were not affected the public. When consider about health and safety issue, in one year past, 40.21 % had an allergic symptom but only 22.52 % thought that it cause from waste treatment place.

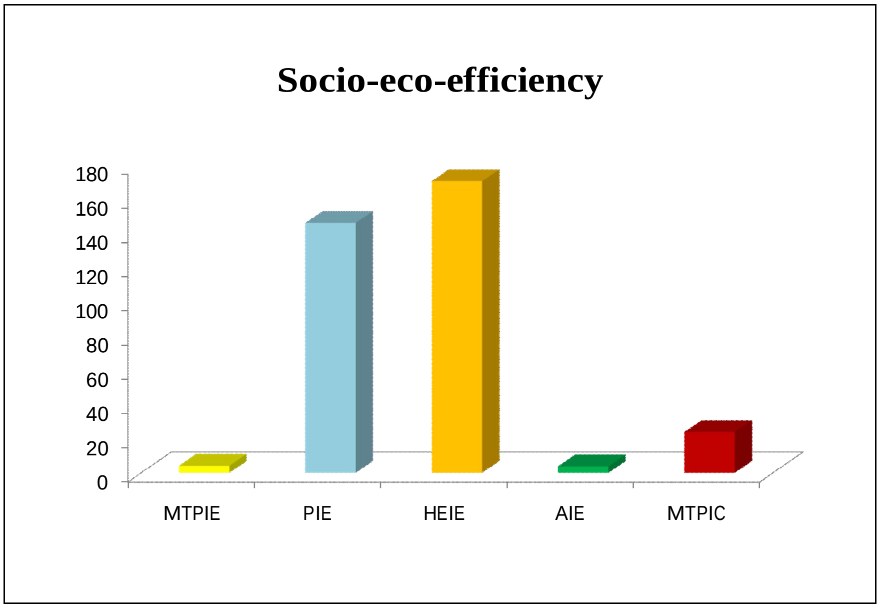

Figure 5.1 The Socio-eco-efficiency average for year 2006 - 2008

The Socio-eco-efficiency results showed the trend and the proportion, which was as same as eco-efficiency trend, the social acceptance score can decrease Socio-eco-efficiency. The social acceptation score have only one value because the structure of industrial estate in MTPIC area is coexist then the waste treatment place is situated around the Map Ta Phut Complex area that cannot separate the people according to the industrial estate.

The Socio-eco-efficiency equation was proved by using the Socio-eco-efficiency result compared with the nearby people opinion from questionnaire. The Socio-eco-efficiency will decrease if the social acceptance score was high.

Then in this study, the conclusions of this research confirms the feasibility of the evaluation method as a decision - making tool in waste management. The main result of this research was could be used as method for developing Socio-Eco-efficiency indicators for sustainability. It also could be used to be a benchmark for the future assessment in another industrial estate or companies that need to increase the positive environmental performance of an industry in relation to economic value creation and to evaluate the eco-efficiency including the social dimension in the analysis. The study presents the way to approach the sustainable development that including three dimensions as economic, environment and social. In the further studies, it should be focus on the development of appropriate indicators that can assess the social dimension comprehensively that including social change issue, occupation of people, historical, archaeological and cultural importance, public health, living condition, job opportunity, quality of life and mental. In the future, Socio-Eco-efficiency will become more important in the context of sustainability in order to show which processes and products are more favorable than other alternatives.

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APPENDICES

APPENDIX A
TREATMENT METHODS WASTE CODES

Codes	Treatment methods
011	Sorting for selling
021	Storage
031	Use as raw material substitution
032	Return to original producer for disposal
033	Reuse container; to be refilled
039	Other reuse methods
041	Use as fuel substitution or burn for energy recovery
042	Fuel blending
043	Burn for energy recovery
044	Use as co-material in cement kiln or rotary kiln
049	Other recycle methods
051	Solvent reclamation/regeneration
052	Reclamation/regeneration of metal and metal compounds
053	Acid/base regeneration
054	Catalyst regeneration
059	Other recovery unlisted materials
061	Biological treatment
062	Chemical treatment
063	Physical treatment
064	Physico-chemical treatment
065	Physico-chemical treatment of wastewater
066	Direct discharge to central wastewater treatment plant
067	Chemical stabilization
068	Chemical fixation using cementitious and/or pozzolanic material

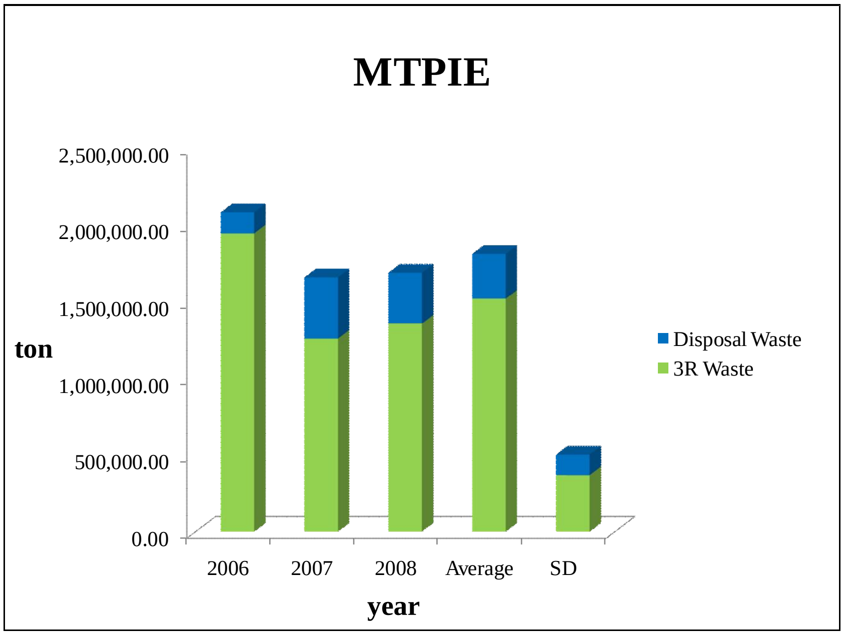
Codes	**Treatment methods (cont.)**
069	Other detoxification methods
071	Sanitary landfill
072	Secure landfill
073	Secure landfill of stabilized and/or solidified wastes
074	Burn for destruction
075	Burn for destruction in hazardous waste incinerator
076	Co-incineration in cement kiln
077	Deep well or underground injection; sea-bed insertion
079	Other disposal methods
081	Collect and export
082	Land reclamation
083	Composting or soil conditioner
084	Animal feed

APPENDIX B
WASTE CODES

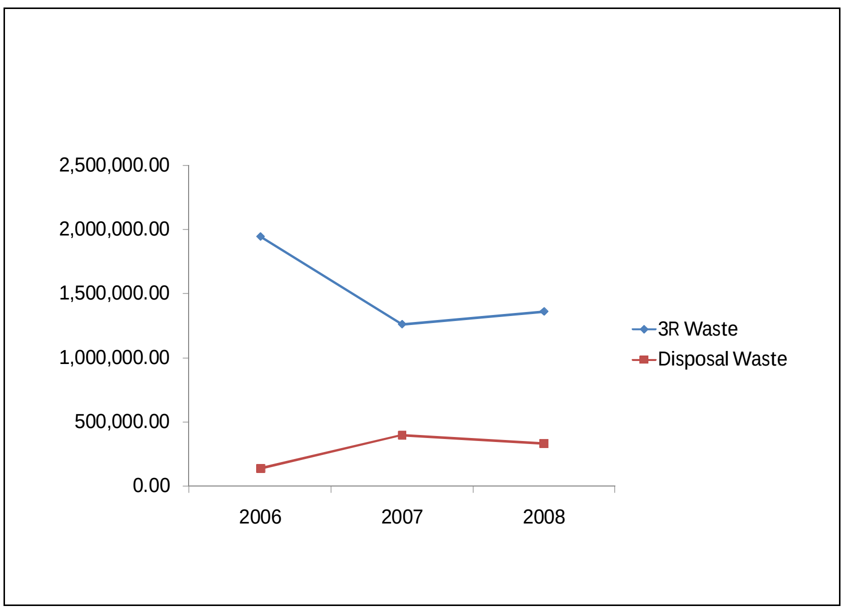
Codes	Waste Description
01	Wastes resulting from exploration, mining, quarrying, physical and chemical treatment of minerals
02	Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing
03	Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard
04	wastes from the leather, fur and textile industries
05	Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal
06	Wastes from inorganic chemical processes
07	Wastes from organic chemical processes
08	Wastes from the manufacture, formulation, supply and use (MFSU) of coatings (paints, varnishes and vitreous enamels), adhesives, sealant and printing inks
09	Wastes from the photographic industry
10	Wastes from thermal processes
11	Wastes from chemical surface treatment and coating of metals and other materials; non-ferrous hydro-metallurgy
12	Wastes from shaping and physical and mechanical surface treatment of metals and plastics
13	Oil wastes and wastes of liquid fuels (except edible oils)
14	Waste organic solvents, refrigerants and propellants
15	Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified

Codes	**Waste Description (cont.)**
16	Wastes not otherwise specified in the list
17	Construction and demolition wastes (including excavated soil from contaminated sites)
18	Wastes from natal care, diagnosis, treatment or prevention of disease in humans
19	wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use

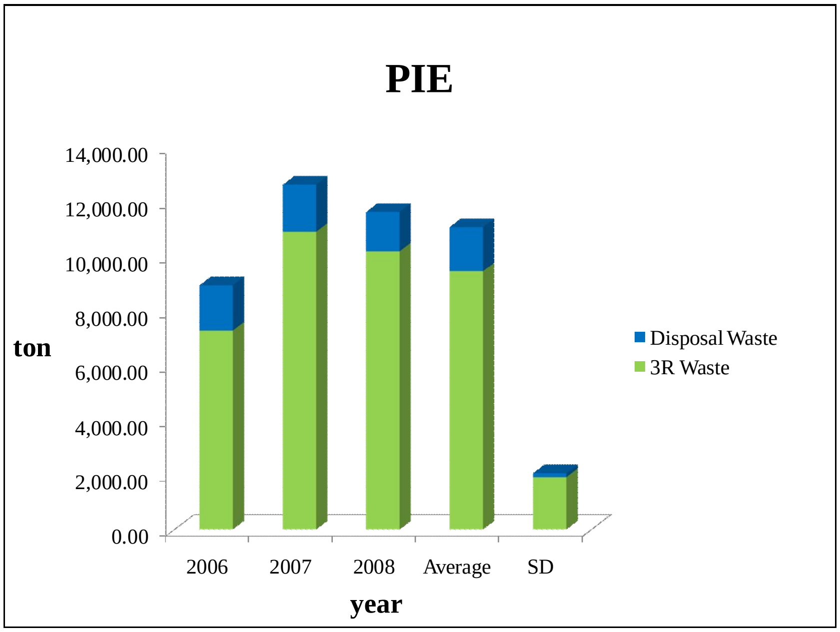
APPENDIX C
TREND OF DISPOSAL AND 3R WASTE



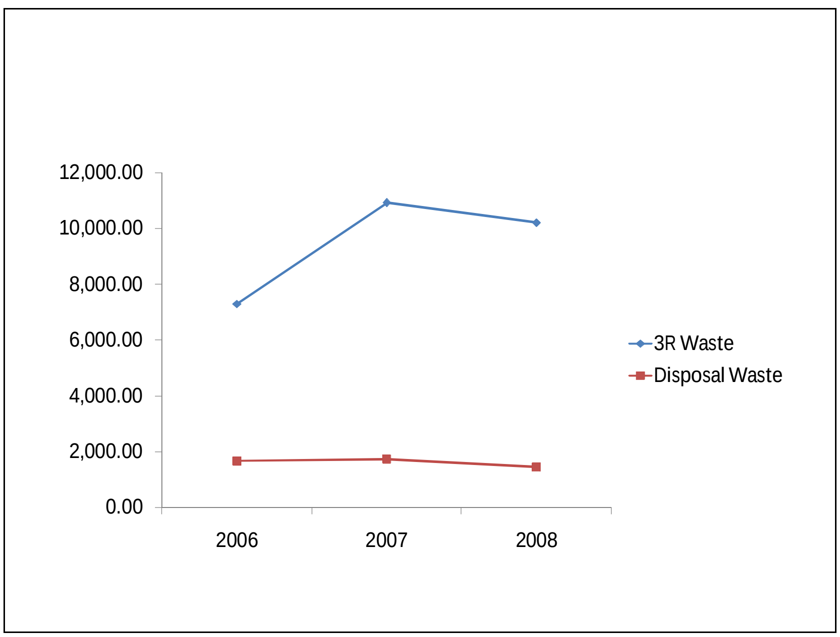
Proportion between disposal waste and 3R waste from MTPIE



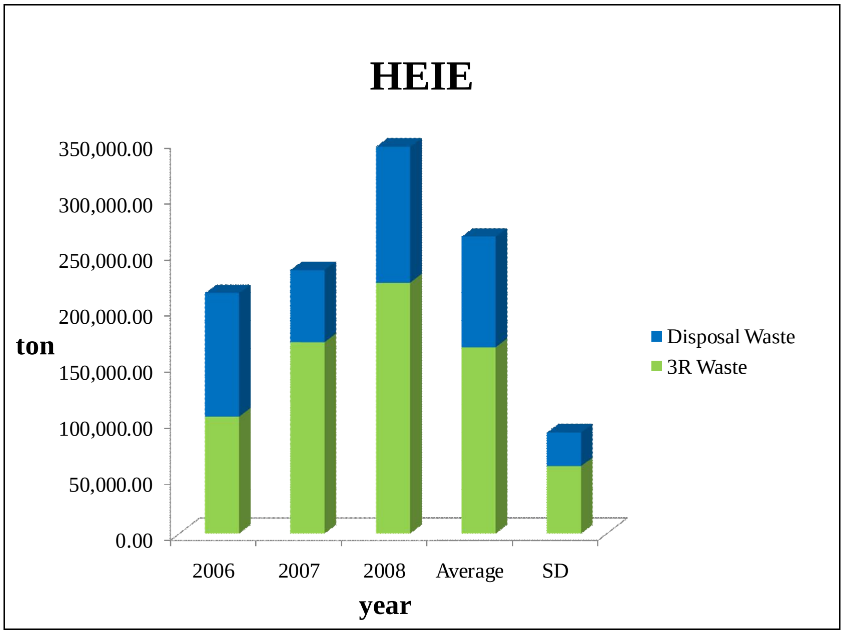
Trend between disposal waste and 3R waste from MTPIE



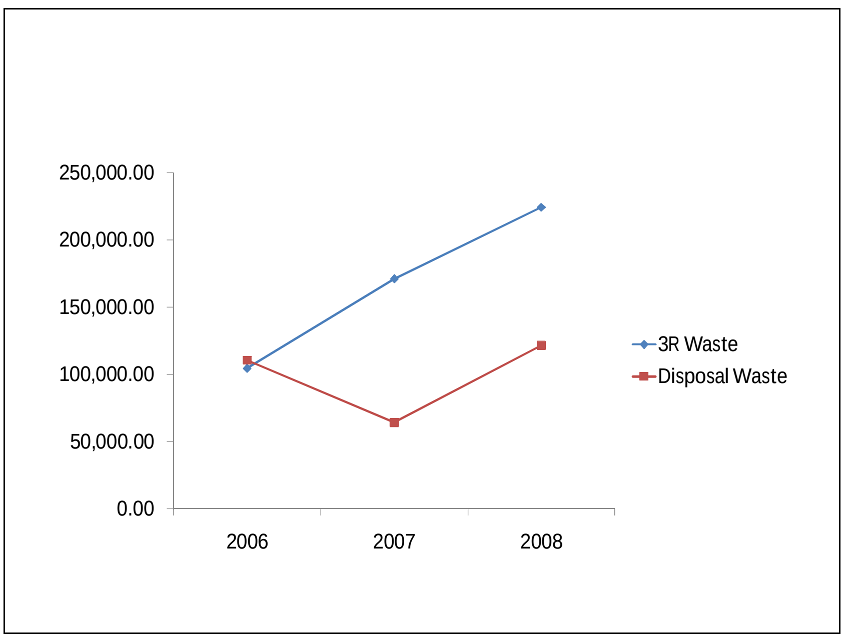
Proportion between disposal waste and 3R waste from PIE



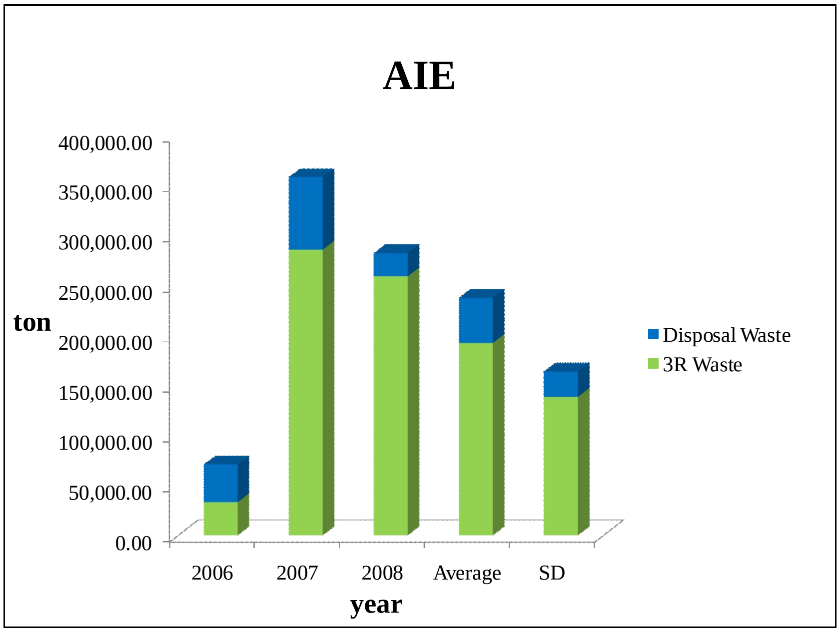
Trend between disposal waste and 3R waste from PIE



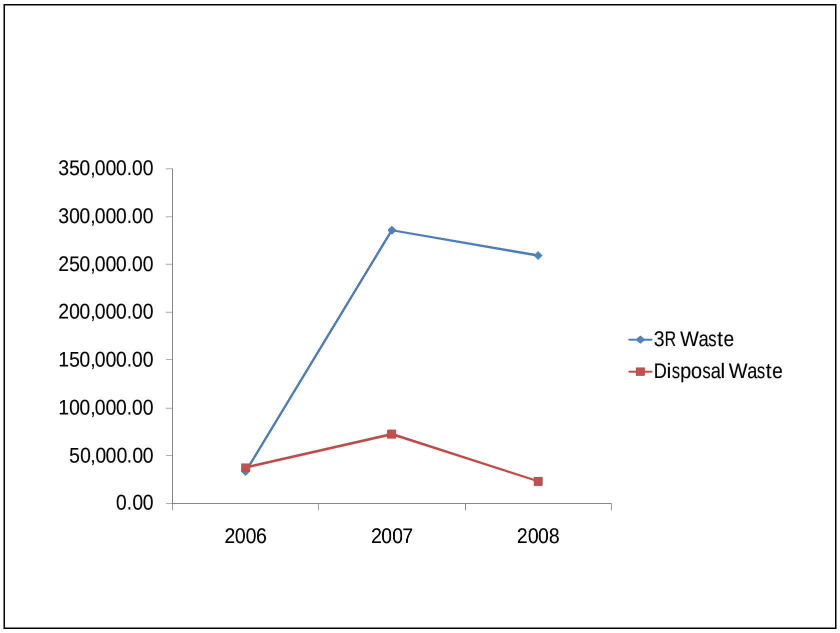
Proportion between disposal waste and 3R waste from HEIE



Trend between disposal waste and 3R waste from HEIE



Proportion between disposal waste and 3R waste from AIE



Trend between disposal waste and 3R waste from HEIE

APPENDIX D
DATA RECORD FORM

การพัฒนาดัชนีชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจ สังคม สำหรับการประเมินกากของเสียอุตสาหกรรม จากนิคมอุตสาหกรรมในเขตพื้นที่มาบตาพุด จ.ระยอง

วัตถุประสงค์

เพื่อทำการพัฒนาตัวชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจ ที่มีมิติทางสังคมร่วมในการประเมินด้วย โดยทำการประเมินกับกากของเสียอุตสาหกรรม (Industrial Waste) ตั้งแต่ปี พศ.2551 ถึง พ.ศ.2552 ที่เกิดจากนิคมอุตสาหกรรมในเขตพื้นที่มาบตาพุด จังหวัดระยอง

คำชี้แจงในการตอบแบบสอบถาม

แบบสอบถามนี้แบ่งออกเป็น 4 ส่วน ดังนี้

ส่วนที่ 1 ข้อมูลทั่วไปของผู้ให้สัมภาษณ์

ส่วนที่ 2 การประกอบอาชีพและสภาพเศรษฐกิจ

ส่วนที่ 3 ผลกระทบทางสิ่งแวดล้อมที่เกิดจากสถานที่บำบัดมูลฝอยในพื้นที่

ส่วนที่ 4 ข้อมูลด้านสาธารณสุขและความปลอดภัย

ให้ผู้ตอบแบบสอบถามทำเครื่องหมาย / ในช่อง ☐ หน้าตัวเลือก และกรอกข้อความในช่องว่างตามความเป็นจริง ขอขอบพระคุณผู้ตอบแบบสอบถามทุกท่านมา ณ ที่นี้

ผู้วิจัย

การวิจัย : การพัฒนาดัชนีชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจ สังคม สำหรับการประเมินกากของเสียอุตสาหกรรม จากนิคมอุตสาหกรรมในเขตพื้นที่มาบตาพุด จ.ระยอง

ให้ผู้ตอบแบบสอบถามทำเครื่องหมาย/ ในช่อง☐ หน้าตัวเลือก และกรอกข้อความในช่องว่างตามความเป็นจริง

ส่วนที่ 1 ข้อมูลทั่วไปของผู้ให้สัมภาษณ์

1. เพศของผู้ให้สัมภาษณ์
   - ☐ ชาย ☐ หญิง
2. อายุของผู้ให้สัมภาษณ์
   - ☐ 20 – 35 ปี ☐ 36 – 60 ปี
   - ☐ ตั้งแต่61 ปีขึ้นไป
3. ระดับการศึกษาของผู้ให้สัมภาษณ์
   - ☐ ประถมศึกษา ☐ มัธยมศึกษา
   - ☐ วิชาชีพ/อนุปริญญา ☐ ไม่ได้รับการศึกษา
   - ☐ อื่นๆ ระบุ________
4. จำนวนคนที่อาศัยอยู่จริงในครัวเรือน
   - ☐ 1 – 2 คน ☐ 3 – 7 คน
   - ☐ ตั้งแต่8 คนขึ้นไป
5. ระยะเวลาที่อาศัยอยู่ที่พักปัจจุบัน
   - ☐ น้อยกว่า5 ปี ☐5 – 20 ปี
   - ☐ 21 – 40 ปี ☐ตั้งแต่41 ปีขึ้นไป
6. ทิศที่ตั้งบ้าน/ระยะห่างโดยประมาณ จากสถานที่กำจัดมูลฝอย
   - ☐ ทิศเหนือ ☐ ทิศใต้
   - ☐ ทิศตะวันออก ☐ ทิศตะวันตก
7. การยอมรับต่อระยะห่างระหว่างบ้านกับสถานที่กำจัดมูลฝอย
   - ☐ เห็นด้วย/ยอมรับได้ ☐ ไม่เห็นด้วย/ยอมรับไม่ได้
8. แหล่งน้ำดื่มหลัก
   - ☐ น้ำบรรจุขวด ☐ น้ำฝน
   - ☐ น้ำประปา ☐ น้ำบาดาล
   - ☐ บ่อน้ำตื้น

9. แหล่งน้ำใช้หลัก

- ☐ น้ำประปา ☐ น้ำบาดาล
- ☐ บ่อน้ำตื้น ☐ แหล่งน้ำธรรมชาติ
- ☐ สระขุด

ส่วนที่ 2 การประกอบอาชีพและสภาพเศรษฐกิจ

10. อาชีพของผู้ให้สัมภาษณ์

- ☐ ค้าขาย ☐ ประกอบธุรกิจส่วนตัว
- ☐ เกษตรกรรม ☐ รับจ้างทั่วไป
- ☐ รับราชการ/รัฐวิสาหกิจ ☐ พนักงานบริษัท/เอกชน
- ☐ ไม่ได้ประกอบอาชีพ

11. จำนวนสมาชิกที่ทำงานในแหล่งบำบัดขยะ ระบุ______________ คน

12. รายได้รวมของครัวเรือน

- ☐ น้อยกว่า 3,000 บาท/ เดือน ☐ 3,000 - 6,000 บาท/ เดือน
- ☐ 6,001 – 10,000 บาท/ เดือน ☐ 10,001 – 15,000 บาท/ เดือน
- ☐ มากกว่า 15,000 บาท/ เดือน

ส่วนที่ 3 ผลกระทบทางสิ่งแวดล้อมที่เกิดจากสถานที่บำบัดมูลฝอยในพื้นที่

13. ผลกระทบด้านกลิ่นเหม็น

- ☐ ไม่ได้รับผลกระทบ ☐ ได้รับเล็กน้อย
- ☐ ได้รับปานกลาง ☐ ได้รับรุนแรง

14. ช่วงฤดูกาลที่ได้รับผลกระทบ (ตอบได้มากกว่า 1 ข้อ)

- ☐ ตลอดทั้งปี ☐ ช่วงฤดูร้อน
- ☐ ช่วงฤดูฝน ☐ ช่วงฤดูหนาว
- ☐ ไม่แน่นอน

15. ช่วงเวลาที่ได้รับผลกระทบ (ตอบได้มากกว่า 1 ข้อ)

- ☐ ตลอดทั้งวัน ☐ ช่วงเช้า
- ☐ ช่วงกลางวัน ☐ ช่วงเย็น
- ☐ ช่วงกลางคืน ☐ ไม่แน่นอน

16. ผลกระทบด้านเสียง

☐ ไม่ได้รับผลกระทบ ☐ มีเสียงดังเล็กน้อย

☐ มีเสียงดังปานกลาง ☐ มีเสียงดังรุนแรง

17. ช่วงเวลาที่ได้รับผลกระทบ (ตอบได้มากกว่า 1 ข้อ)

☐ ตลอดทั้งวัน ☐ ช่วงเช้า

☐ ช่วงกลางวัน ☐ อื่นๆระบุ______________

18. ผลกระทบด้านน้ำเสีย/น้ำชะล้างของเสีย

☐ ไม่ได้รับผลกระทบ ☐ ได้รับผลกระทบน้อย

☐ ได้รับผลกระทบปานกลาง ☐ ได้รับผลกระทบรุนแรง

19. ช่วงฤดูกาลที่ได้รับผลกระทบ (ตอบได้มากกว่า 1 ข้อ)

☐ ตลอดทั้งปี ☐ ช่วงฤดูร้อน

☐ ช่วงฤดูฝน ☐ ช่วงฤดูหนาว

☐ ไม่แน่นอน

20. ผลกระทบด้านการคมนาคม

☐ ได้รับผลกระทบ ☐ ไม่ได้รับผลกระทบ

21. กรณีที่ได้รับผลกระทบ สภาพปัญหาของผลกระทบ (ตอบได้มากกว่า 1 ข้อ)

☐ สภาพจราจรแออัด ☐ กีดขวางเส้นทางจราจร

☐ พื้นที่ผิวจราจรเสียหาย ☐ ฝุ่น/ควันจากการจราจร

22. ระดับของผลกระทบ

☐ น้อย

☐ ปานกลาง

☐ มาก

23. ช่วงเวลาที่ได้รับผลกระทบ (ตอบได้มากกว่า 1 ข้อ)

☐ ตลอดทั้งวัน ☐ ช่วงเช้า

☐ ช่วงกลางวัน ☐ อื่นๆระบุ______________

24. ระยะห่างจากสถานที่บำบัดมูลฝอยกับครัวเรือน

☐ เหมาะสม/ยอมรับได้

☐ ไม่เหมาะสม/ยอมรับไม่ได้

25. ผลกระทบต่อทัศนียภาพ

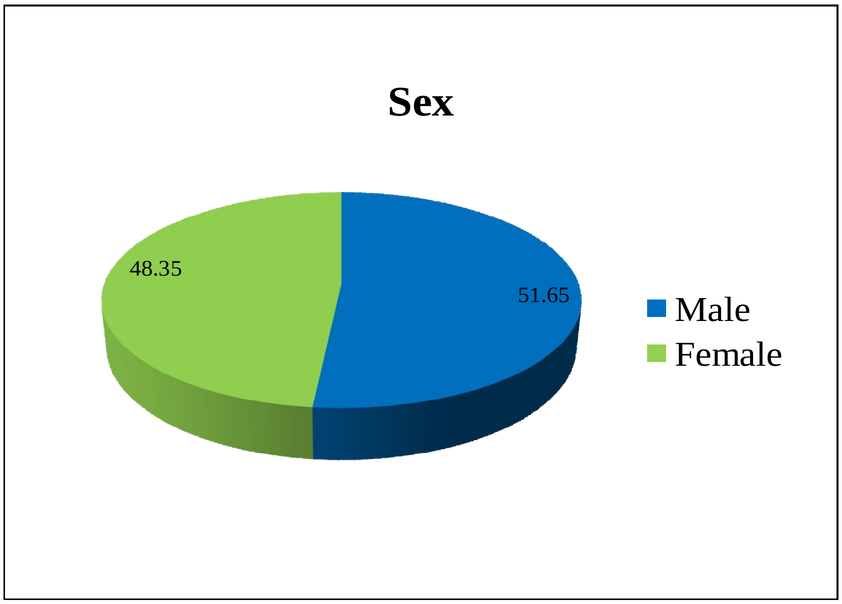
☐ ไม่ส่งผลกระทบต่อการเปลี่ยนแปลงทัศนียภาพ

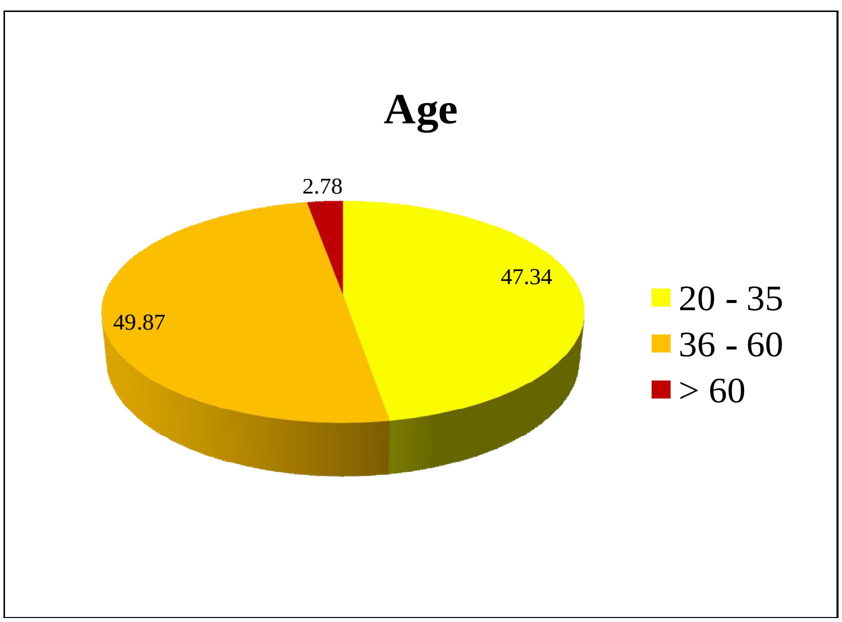
- ☐ ส่งผลกระทบต่อการเปลี่ยนแปลงทัศนียภาพน้อย
- ☐ ส่งผลกระทบต่อการเปลี่ยนแปลงทัศนียภาพปานกลาง
- ☐ ส่งผลกระทบต่อการเปลี่ยนแปลงทัศนียภาพรุนแรง

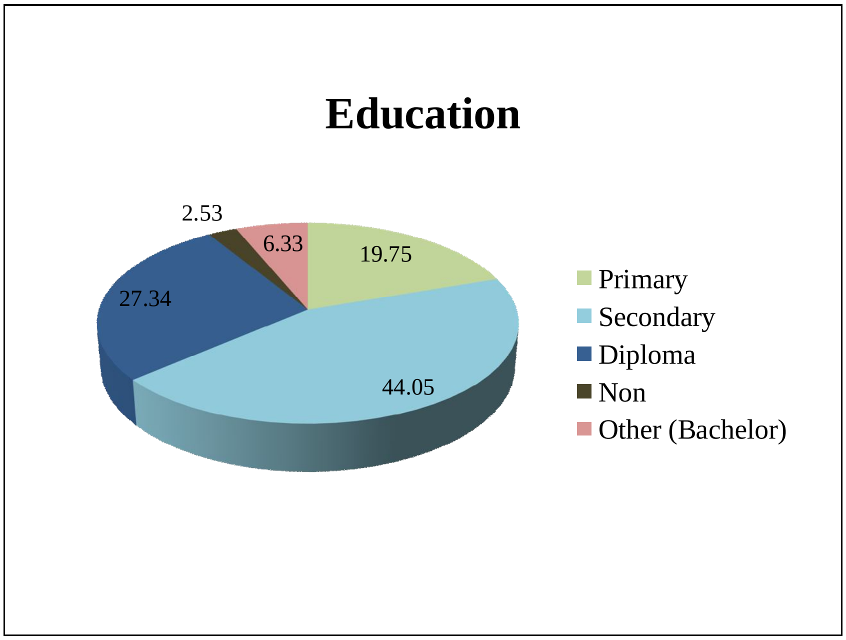
ส่วนที่ 4 ข้อมูลด้านสาธารณสุขและความปลอดภัย

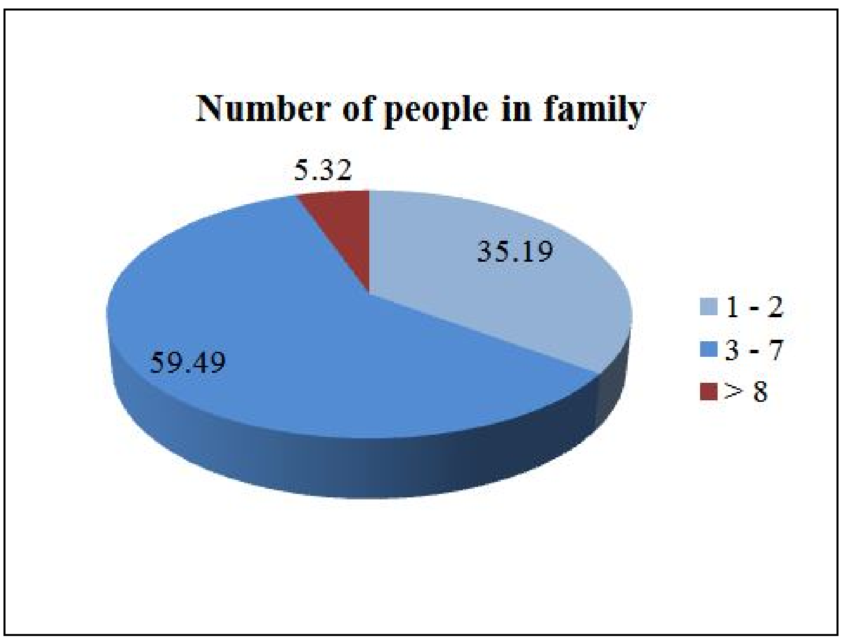
26. การเจ็บป่วยของสมาชิกในครัวเรือนในรอบ 1 ปี
    - ☐ ไม่มีผู้เจ็บป่วย
    - ☐ มีผู้เจ็บป่วย
27. ถ้ามีสมาชิกในครัวเรือนเจ็บป่วย เจ็บป่วยด้วยโรค(ตอบได้มากกว่า1 ข้อ)
    - ☐ ไข้หวัด ☐ ท้องเสีย
    - ☐ ไข้เลือดออก ☐ นิ่ว
    - ☐ ภูมิแพ้ ☐ โรคประจำตัว
    - ☐ อื่นๆ ระบุ________________
28. เมื่อมีอาการเจ็บป่วยไปรักษาที่ (ตอบได้มากกว่า1 ข้อ)
    - ☐ โรงพยาบาล ☐ สถานีอนามัย
    - ☐ คลินิก ☐ ซื้อยามากินเอง
    - ☐ สถานบริการสาธารณสุขอื่นๆ ระบุ_____________
29. สาเหตุที่เจ็บป่วยเนื่องจาก (ตอบได้มากกว่า1 ข้อ)
    - ☐ การเปลี่ยนแปลงสภาพอากาศ ☐ โรคประจำตัว
    - ☐ ยุงลาย ☐ สถานที่บำบัดมูลฝอย
    - ☐ ไม่ทราบสาเหตุ ☐ อื่นๆ ระบุ___________________
30. อุบัติเหตุที่เกิดขึ้นกับสถานที่บำบัดมูลฝอย
    - ☐ ไม่เกิดเลยในช่วง 10 ปี ☐ เกิด 1 ครั้งในช่วง5-10 ปี
    - ☐ เกิด 1 ครั้งในช่วง1-5 ปี ☐ เกิดมากกว่าปี 1 ครั้งใน1
31. ความรู้สึกด้านความปลอดภัยเกี่ยวกับสถานที่บำบัดมูลฝอย
    - ☐ ไม่มีความกังวลในเรื่องความปลอดภัยของระบบบำบัดมูลฝอย
    - ☐ มีความกังวลในเรื่องความปลอดภัยของระบบบำบัดมูลฝอยเล็กน้อย
    - ☐ มีความกังวลในเรื่องความปลอดภัยของระบบบำบัดมูลฝอยปานกลาง
    - ☐ มีความกังวลในเรื่องความปลอดภัยของระบบบำบัดมูลฝอยมาก

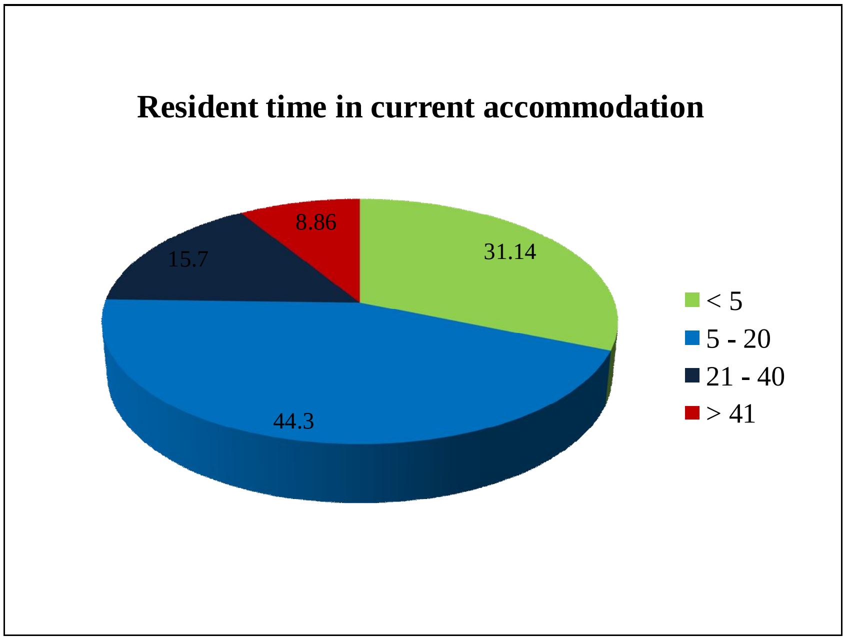
APPENDIX E
RESULT OF QUESTIONNAIRE

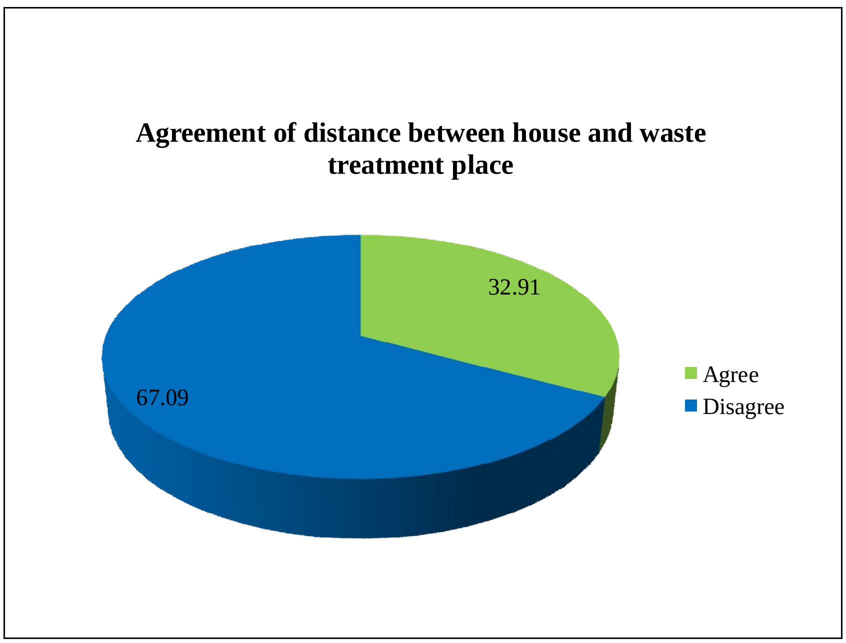


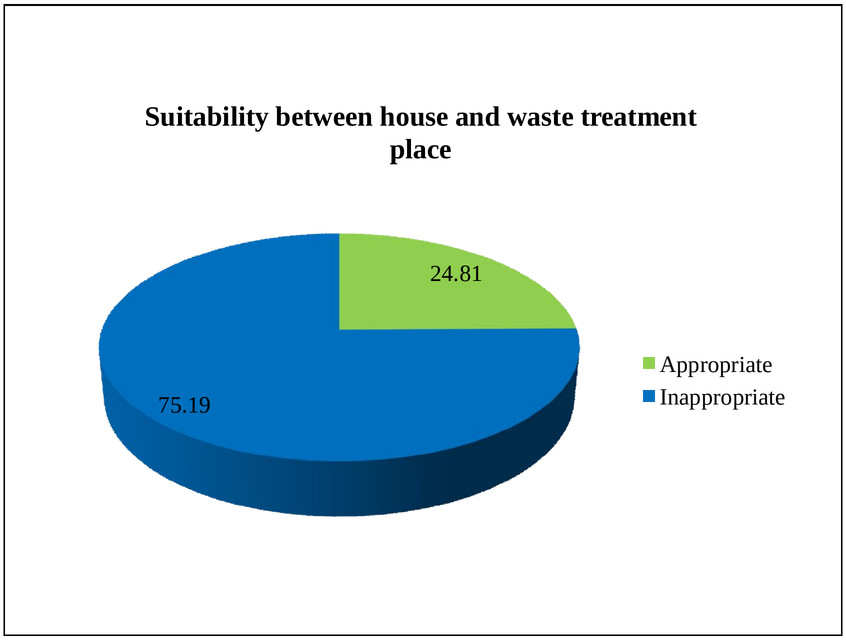


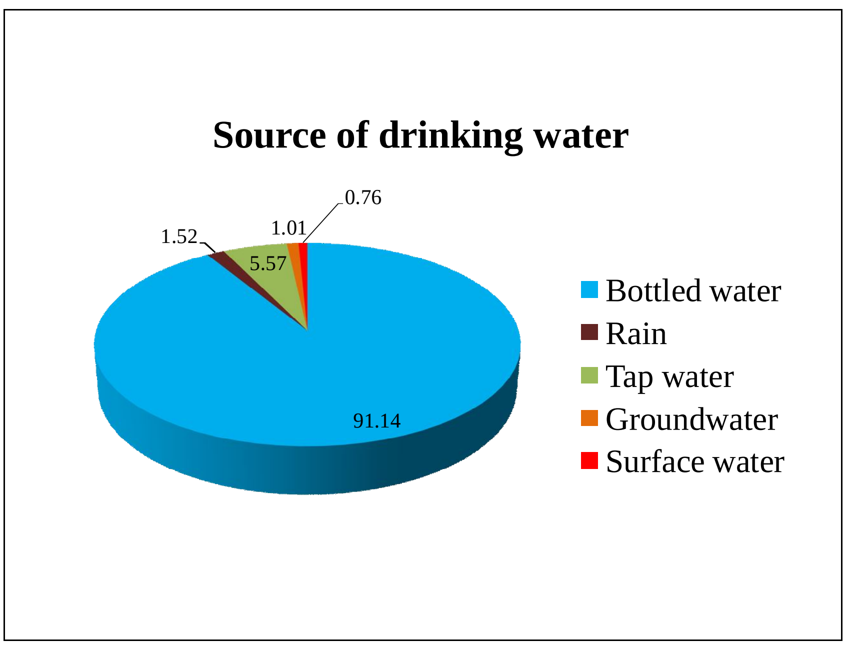

Education
2.53
6.33
19.75
27.34
44.05
Primary
Secondary
Diploma
Non
Other (Bachelor)

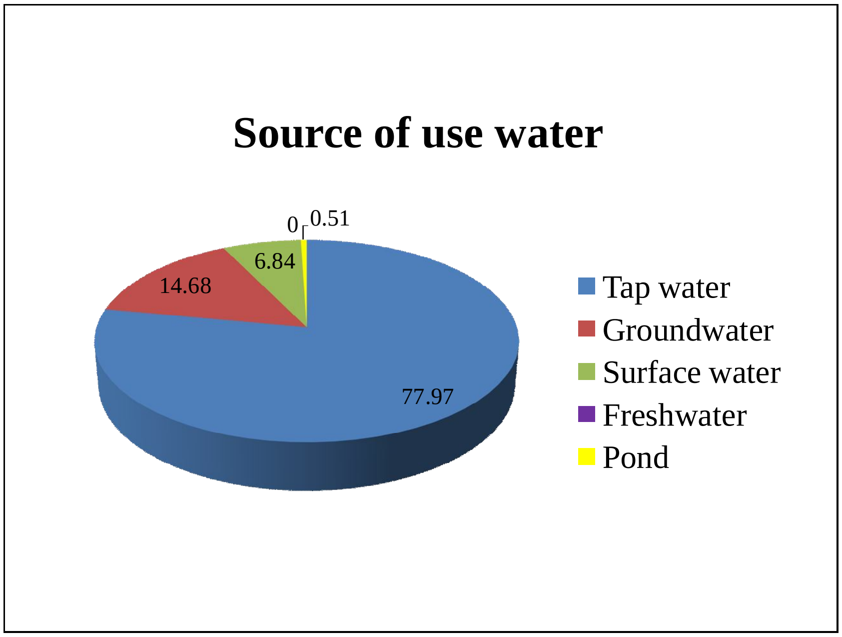

Number of people in family
5.32
35.19
59.49
1 - 2
3 - 7
> 8

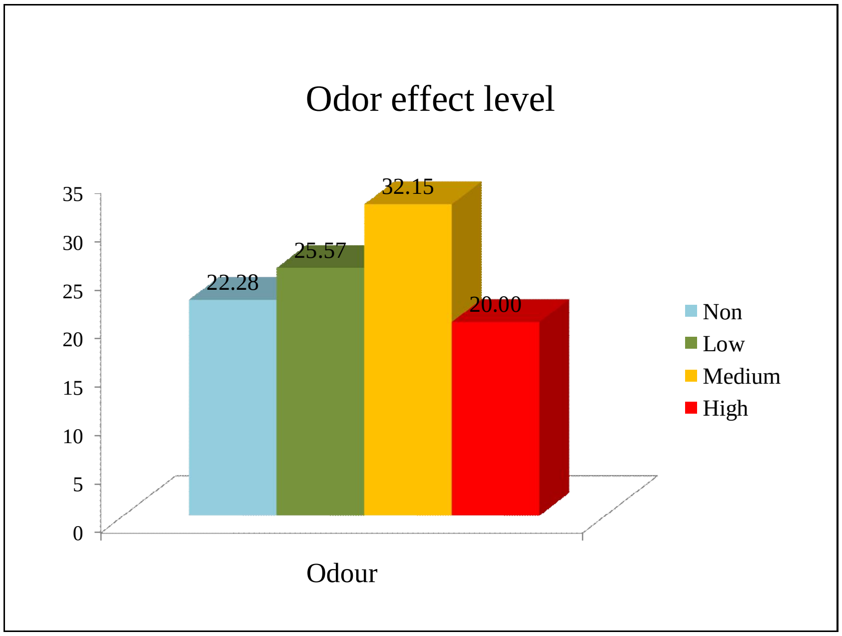

Resident time in current accommodation
8.86
15.7
31.14
44.3
< 5
5 - 20
21 - 40
> 41

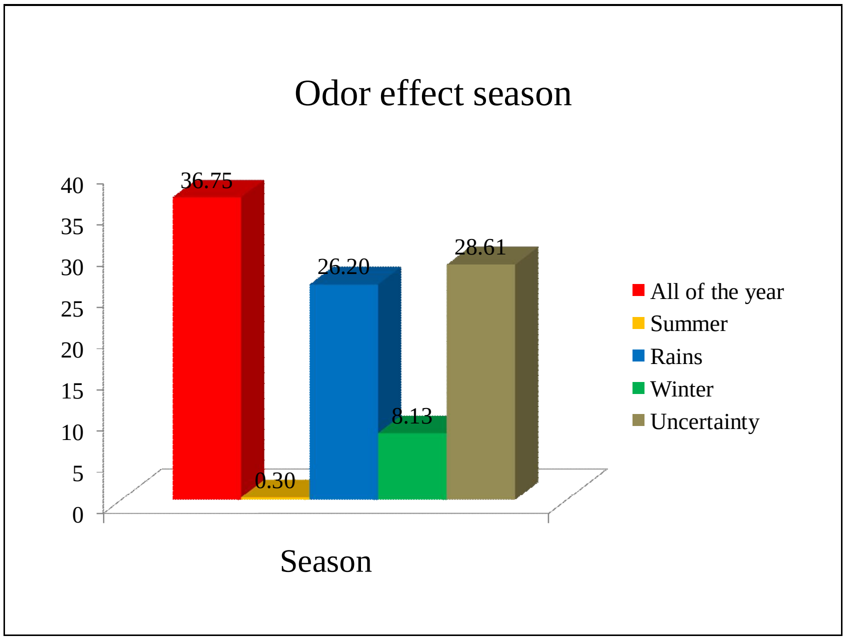

Agreement of distance between house and waste treatment place
32.91
67.09
Agree
Disagree

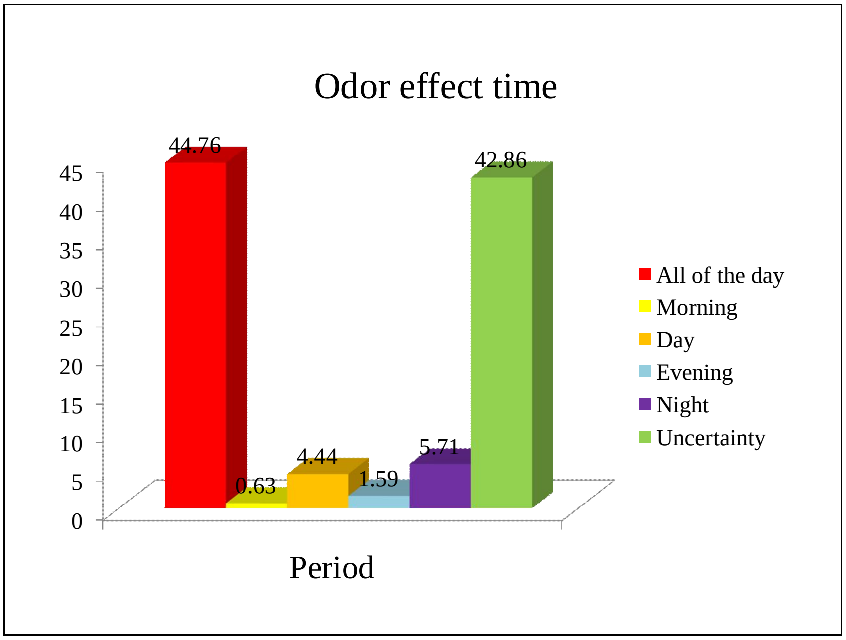

Suitability between house and waste treatment place
24.81
75.19
Appropriate
Inappropriate

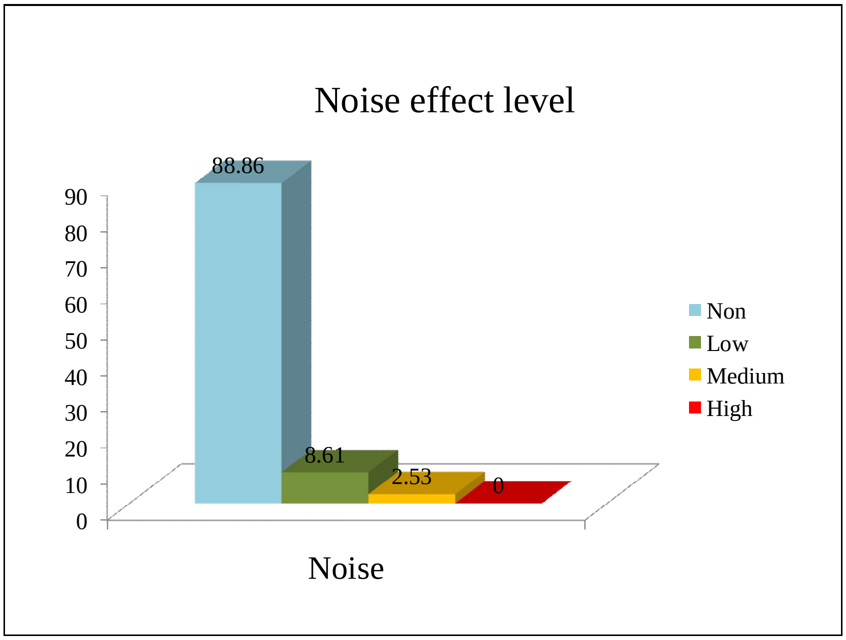

Source of drinking water
0.76
1.52
1.01
5.57
91.14
Bottled water
Rain
Tap water
Groundwater
Surface water

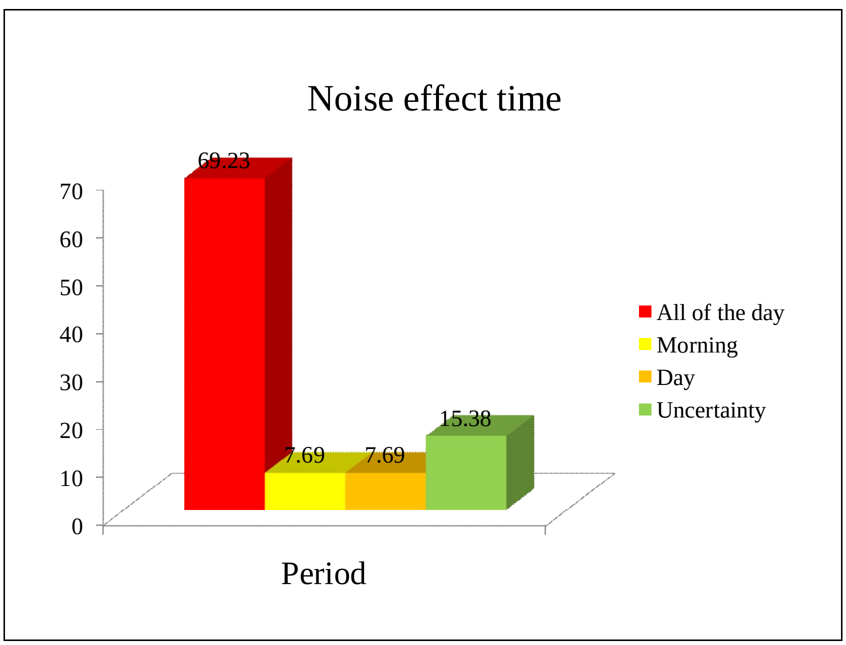

Source of use water
0
0.51
6.84
14.68
77.97
Tap water
Groundwater
Surface water
Freshwater
Pond

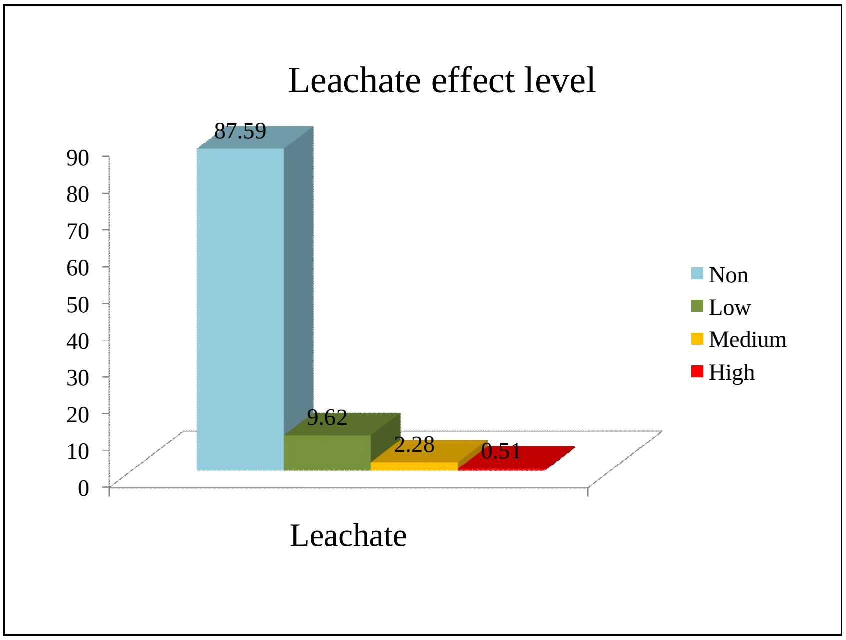

Odor effect level
35
30
25
20
15
10
5
0
22.28
25.57
32.15
20.00
Non
Low
Medium
High
Odour

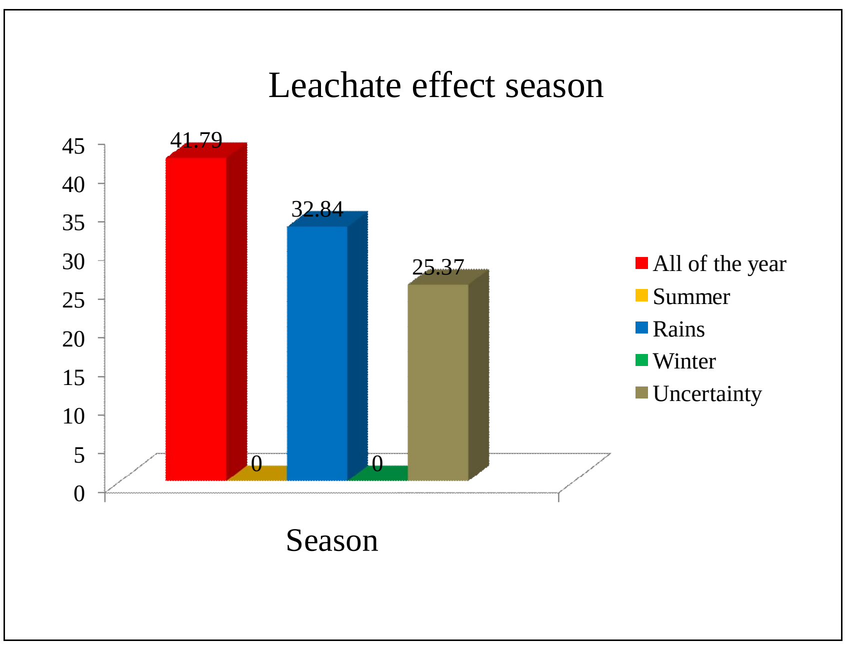

Odor effect season
40
35
30
25
20
15
10
5
0
36.75
0.30
26.20
8.13
28.61
All of the year
Summer
Rains
Winter
Uncertainty
Season

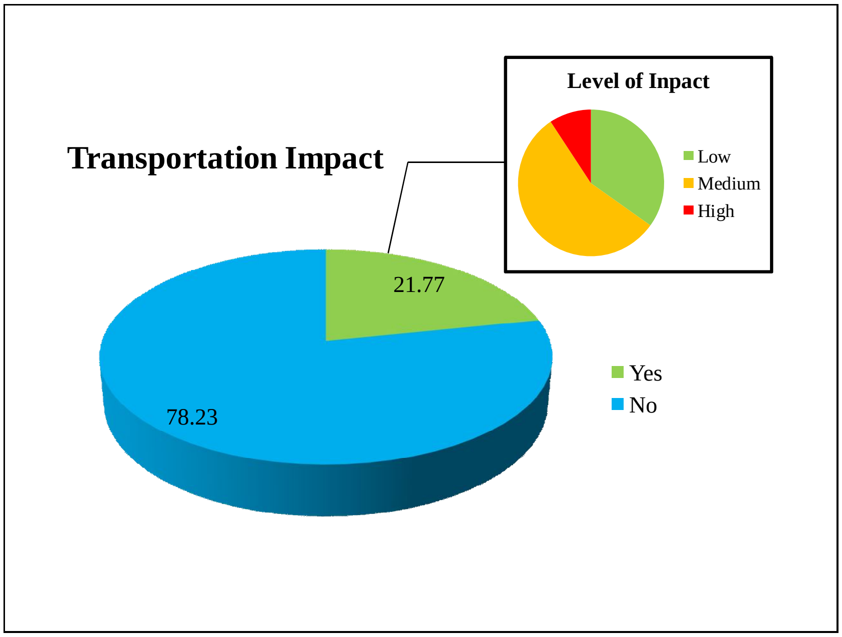

Odor effect time
45
40
35
30
25
20
15
10
5
0
44.76
0.63
4.44
1.59
5.71
42.86
All of the day
Morning
Day
Evening
Night
Uncertainty
Period

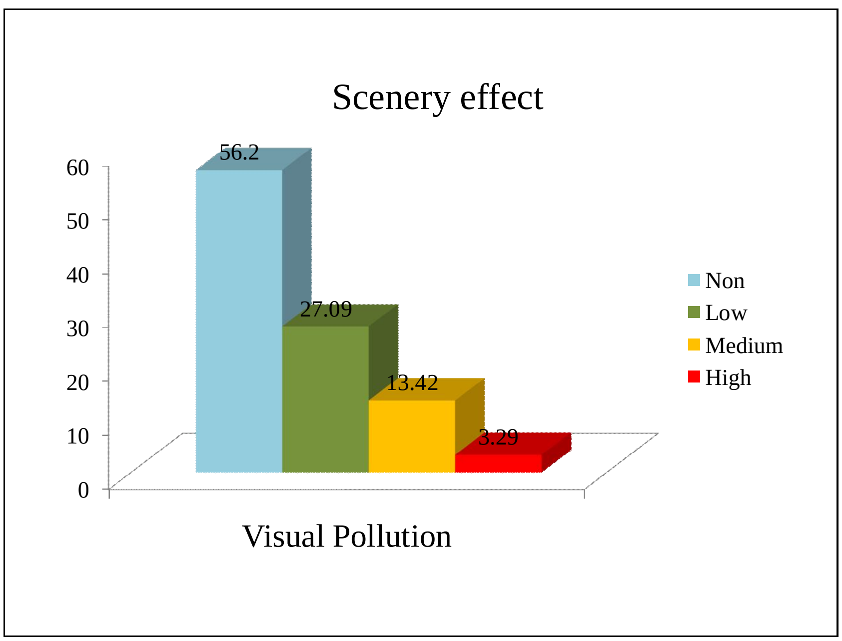

Noise effect level
88.86
8.61
2.53
0
90
80
70
60
50
40
30
20
10
0
Non
Low
Medium
High
Noise

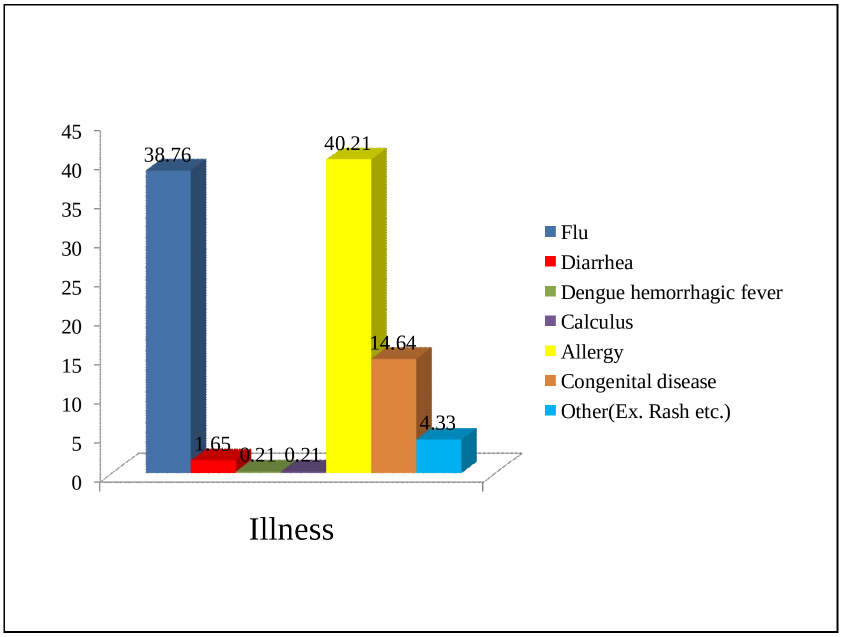

Noise effect time
69.23
7.69
7.69
15.38
70
60
50
40
30
20
10
0
All of the day
Morning
Day
Uncertainty
Period

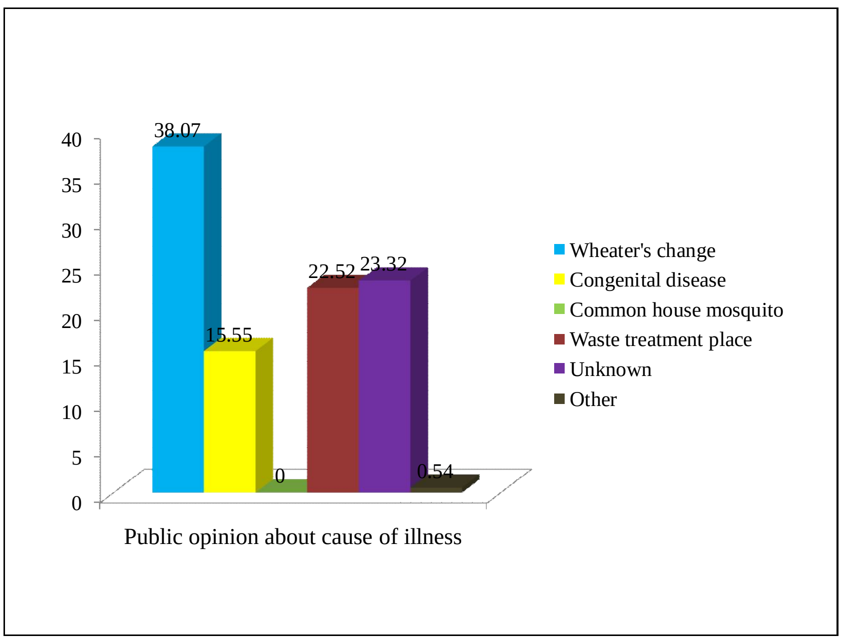

Leachate effect level
87.59
90
80
70
60
50
40
30
20
10
0
9.62
2.28
0.51
Leachate
Non
Low
Medium
High

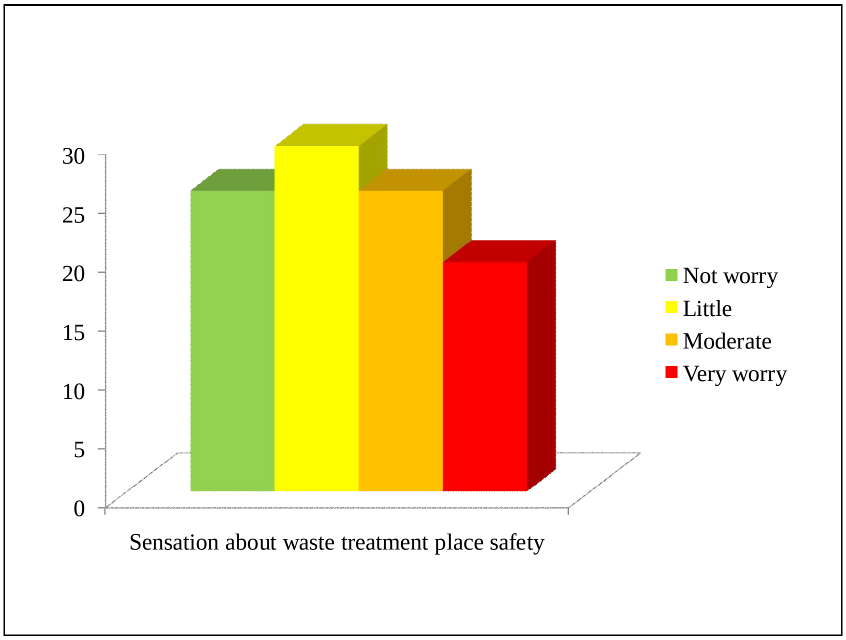

Leachate effect season
41.79
45
40
35
30
25
20
15
10
5
0
32.84
25.37
0
0
Season
All of the year
Summer
Rains
Winter
Uncertainty


Transportation Impact
Level of Inpact
Low
Medium
High
21.77
78.23
Yes
No


Scenery effect
60
50
40
30
20
10
0
56.2
27.09
13.42
3.29
Non
Low
Medium
High
Visual Pollution


45
40
35
30
25
20
15
10
5
0
38.76
1.65
0.21
0.21
40.21
14.64
4.33
Illness
Flu
Diarrhea
Dengue hemorrhagic fever
Calculus
Allergy
Congenital disease
Other(Ex. Rash etc.)


40
35
30
25
20
15
10
5
0
38.07
15.55
0
22.52
23.32
0.54
Public opinion about cause of illness
Wheater's change
Congenital disease
Common house mosquito
Waste treatment place
Unknown
Other


30
25
20
15
10
5
0
Not worry
Little
Moderate
Very worry
Sensation about waste treatment place safety

APPENDIX F
THE QUESTIONNAIRE SAMPLING LOCATIONS

The locations of four collecting site were located using GPS as follows;

Location 1 47P 0660723 UTM 1527705
Location 2 47P 0730702 UTM 1407854
Location 3 47P 0731056 UTM 1408061
Location 4 47P 0730914 UTM 1406967

BIOGRAPHY

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