

ASIAN REGIONAL RESEARCH PROGRAMME ON SUSTAINABLE SOLID WASTE LANDFILL MANAGEMENT IN ASIA

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SUMMARY: With the rapid urbanization and economic development in Asia, the quantity of solid waste generated has increased greatly. In most Asian countries, the most common practice of disposing the solid waste is open dumping, which is the easiest and considered to be the cheapest method of removing waste from the immediate environment. This predicament made an enormous impact to the society, culture, and most especially to health and environment. In response to the problem, the Swedish International Development Cooperation Agency (Sida) initiated the Asian Regional Research Programme on Environmental Technologies (ARRPET), which aimed to resolve or improve the relevant environmental issues in Asia through a network of researches involving National Research Institutes (NRI) in eight countries. One of the focal researches is on developing Sustainable Solid Waste Landfill Management (SWLF) in Asia that are carried out by four NRIs namely Tongji University, China; Anna University, India; University of Peradeniya, Sri Lanka, Kasertsart University, Thailand and overall coordinated by Asian Institute of Technology (AIT), Thailand. For several years of ARPET's project operation, a unique networking has been the core method responsible for its success. NRIs were specifically chosen from representative Asian countries to collaborate on solving Asia's municipal solid waste problems as they can heed more to the issues than other countries of the world. It has distributed the research load between the four NRI's that eliminates redundancies, maximizes the resources, and effectively uses the expertise to provide better solutions to the solid waste problems. In this manner, lateral rather than vertical direction of communication through the network are emphasized which guarantees sharing of information, confirmation of results, and comparison of outputs. This paper is directed towards the importance of the Sida project and its integrated networking approach.

1. INTRODUCTION

Generation of Municipal Solid Waste (MSW) increases with rapid urbanization due to accelerated socio-economic development. In the developing Asian countries, uncontrolled growth of population and its urban shift further adds to waste generations. The changes in consumption patterns with alterations in the waste characteristics have resulted in a quantum jump in solid waste generation. Inadequate waste management and disposal practices combined with the tropical climatic influence results in increasing environmental problems in Asian region (Visvanathan et al 2004). Nowadays, the urban areas of Asia produce approximately 8 million tones of municipal solid waste per day (World Bank, 1999).

The Swedish International Development Cooperation Agency (Sida) answered to the need of Asia's problems. Sida has developed the project Asian Regional Research Program on Environmental Technology (ARRPET), which aimed to resolve or improve the environmental issues of Asia through researches of a network of National Research Institutes (NRI) from eight Asian countries. The project covers various environmental problems in wastewater, air pollution, solid waste landfill, and hazardous waste. One of the focal researches is on developing Sustainable Solid Waste Landfill Management in Asia (SWLF) that are carried out by four NRIs namely National Engineering Research Center for Urban Pollution Control, Tongji University, China; Centre for Environmental Studies (CES), Anna University, India; Faculty of Agriculture, University of Peradeniya, Sri Lanka, Faculty of Engineering, Kasertsart University, Thailand and overall coordinated by the Environmental Engineering and Management Program, Asian Institute of Technology (AIT), Thailand.

Through the leadership of Sida, a unique networking strategy was formed to effectively achieve the objectives of the project. It highlights the contribution of special knowledge, competence, and experience of the researchers, which is set up to obtain a common goal. Furthermore, it has distributed the research load between the four NRI's that eliminates redundancies, maximizes the resources, and effectively uses the expertise to provide better solutions to the solid waste problems.

2. CONCEPT AND RATIONALE

2.1 Significance of ARPET Sustainable Solid Waste Landfill Management in Asia

The ARPET project on Sustainable Solid Waste Landfill Management in Asia emphasizes the need of Asian developing countries to promote landfill management practices that could sustain the rapid Municipal Solid Waste (MSW) generation especially in the urban areas. In most cities of Asian developing countries, waste management is inadequate: a significant portion of the population does not have access to a waste collection services and only a fraction of the generated waste is actually collected. Systems for transfer, recycling and/or disposal of solid waste are unsatisfactory from the environmental, economic, and financial points (Schubeler. et al, 1996). Open dumps - unfortunately still mostly observed in developing countries - where the waste is dumped in an uncontrolled manner, can be detrimental to the urban environment (Zurbrugg C., 2003). In South and Southeast Asia, more than 90 per cent of all landfills are non-engineered open dump disposal facilities (Ranaweera and Tränkler, 2001). Problems such as shortage of landfill covering, lack of leachate collection and treatment system, inadequate compaction, poor site design, and pickers who would be scavenging at the site are commonly

experienced. Thus, these dump sites are essentially uncontrolled, creating considerable health, safety, and environmental problems (International Source Book, UNEP, 2000).

As a result of low technical standards of both collection and final disposal, MSW ends up to a large extent either in dumpsites or non-engineered landfills. Furthermore, the tropical Asian climate with severe precipitation and high humidity aggravate the problem of waste disposal. The leachate flow from dumpsites increases as a result of intensive downpours that create an endless threat to the aquatic environment. Moreover, landfills without proper management and leachate treatment facilities become a prominent source of pollution that contaminates surface and ground water. Biogas, which are primarily composed of methane (CH₄), carbon dioxide (CO₂), hydrogen sulfide (H₂S), and other inert gases, are generated by the biological degradation of organic matter in landfills. It has been estimated that CH₄ has 20 times greater global warming potential than CO₂ (Ishigaki, et al., 2002). Several cases of outbreaks of diseases are also reported due to poor sanitary condition, waste handling and disposal facilities. In October 1995, the outbreak of plague in Surat, India is considered to have originated from the uncollected solid waste in the city and clogged drains (Eisa and Visvanathan, 2002).

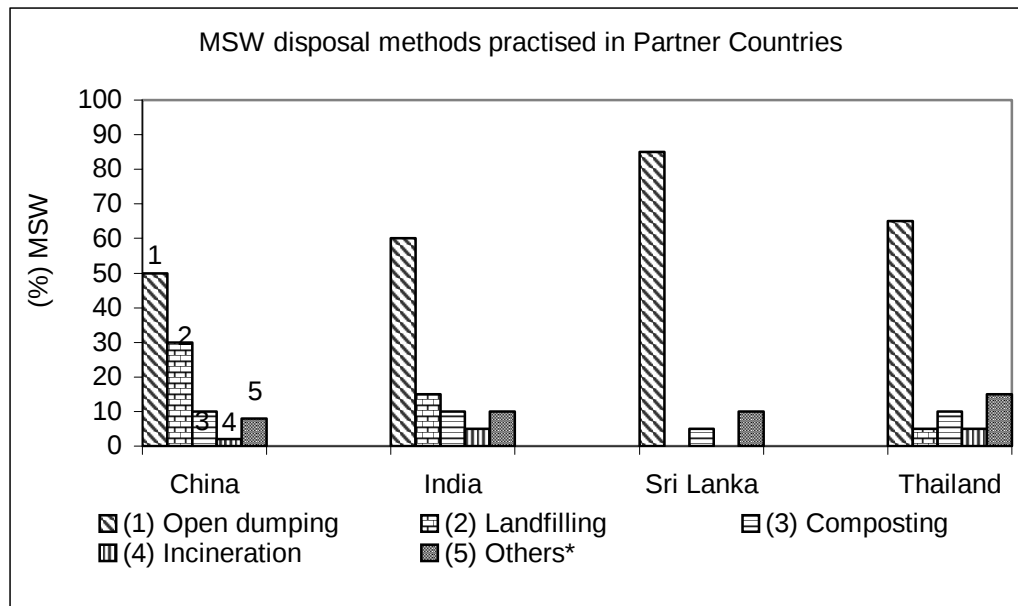
With these prevailing situations at hand, Asia requires a comprehensive research on sustainable solid waste landfill management issues to improve considerably the local environment, to prevent global warming and to protect the health of the people. Therefore, Sida conducted the ARRPET project on Sustainable Solid Waste Landfill Management in Asia, which aims to provide useful guidelines for the government and policy makers involved in urban planning and development, in general, and in particular, to plan and implement sustainable urban solid waste management programme.

The phase I of the SWLF project commenced in January 2001 and completed in June 2004 and phase II continued and is expected to complete by December 2007. The Project Objectives includes technical research, networking among NRIs, policy, and institutional aspects, which could be summarize in the following:

- Identification and development of sustainable, environmentally sound and cost effective solid waste treatment and disposal technologies;
- Compilation of existing practices of solid waste management and basic information about solid waste organization, anthology of training materials, lecture notes, workshop and training programs; and
- Identification of gaps and recommendation in policy and legislation based on data compilation, technical research, and policy dissemination.

2.2 Network of researchers working as a team

The SWLF project under ARRPET was accomplished through four National Research Institutions (NRI) from China, India, Sri Lanka, and Thailand. The NRIs were particularly selected among over 50 countries in Asia to embody the continent's MSW concerns. The choice was made according to the country's size being India and China, the largest nations with the biggest population in Asia, which consist of several metropolitan cities, whereas Thailand and Sri Lanka were medium and small-sized countries, respectively. In addition, four research institutions also exhibits variety in its existing regional setting, waste generation, tropical influences, and cultural practices. In Sri Lanka, the prevalent method of waste disposal is open dumping accounting for more than 85%, while in China; they have 571 landfills, 134 composting units, and 36 incineration plants. Thailand's total MSW generated in the year 2000 was approximately 14 million tons, while India generates about 30,000 tons per day and has continued to accelerate with increasing population (ARRPET, 2004). Figure 1 shows the different solid waste disposal practices in the four partner countries.



*Animal feeding, dumping in water, open burning.

Source: UN, 2000

Figure 1. MSW disposal methods in the studied countries

It could be noticed that open dumping is the common disposal method in the region. In addition, these dumping practices were not maintained properly that it posed an immense threat to the health of the people. Thus, justifies the vast regional research collaboration.

Despite the fact that there are several points of difference in each country's solid waste problems; the main objective of the research remains the same, to provide criterion that could sustain each countries' solid waste landfill management issues.

In order to achieve the project objectives, research proposals were drafted and reviewed. Studies were chosen by each NRI according to their area of expertise with each research assigned to at least two NRIs. The following are the major topics of the proposal.

- Dumpsite rehabilitation and landfill mining
- Mechanical biological pre-treatment (MBPT)
- Biological methane oxidation
- Landfill leachate treatment technologies
- Landfill lysimeter simulation.

Each major topic was chosen by at least two or more NRIs, which would allow conducting a collaborative research and comparing the results. The distribution of workloads among the NRIs (Figure 2) allows manifestation of dynamism and full participation of the researchers as they showcase their research abilities in their respective field of expertise. Since the research proposal was assigned to at least two NRIs, this manner will surely enhance each researcher's attitudes of sharing in terms of ideas and results. Apart from the technical research, national conferences and workshops were organized to update the network on the progress of the respective studies. This could also be a venue for the collaborating NRIs to compare their results and data. Due to this vigorous networking structure of the project, a lateral rather than vertical direction of communication through the network was observed, where the content of communication between bodies are considered advice and recommendations rather than instructions and decisions. The versatility of the researchers in handling various research studies at the same time has also benefited the project greatly in terms of faster generation of technical results at short period of time.

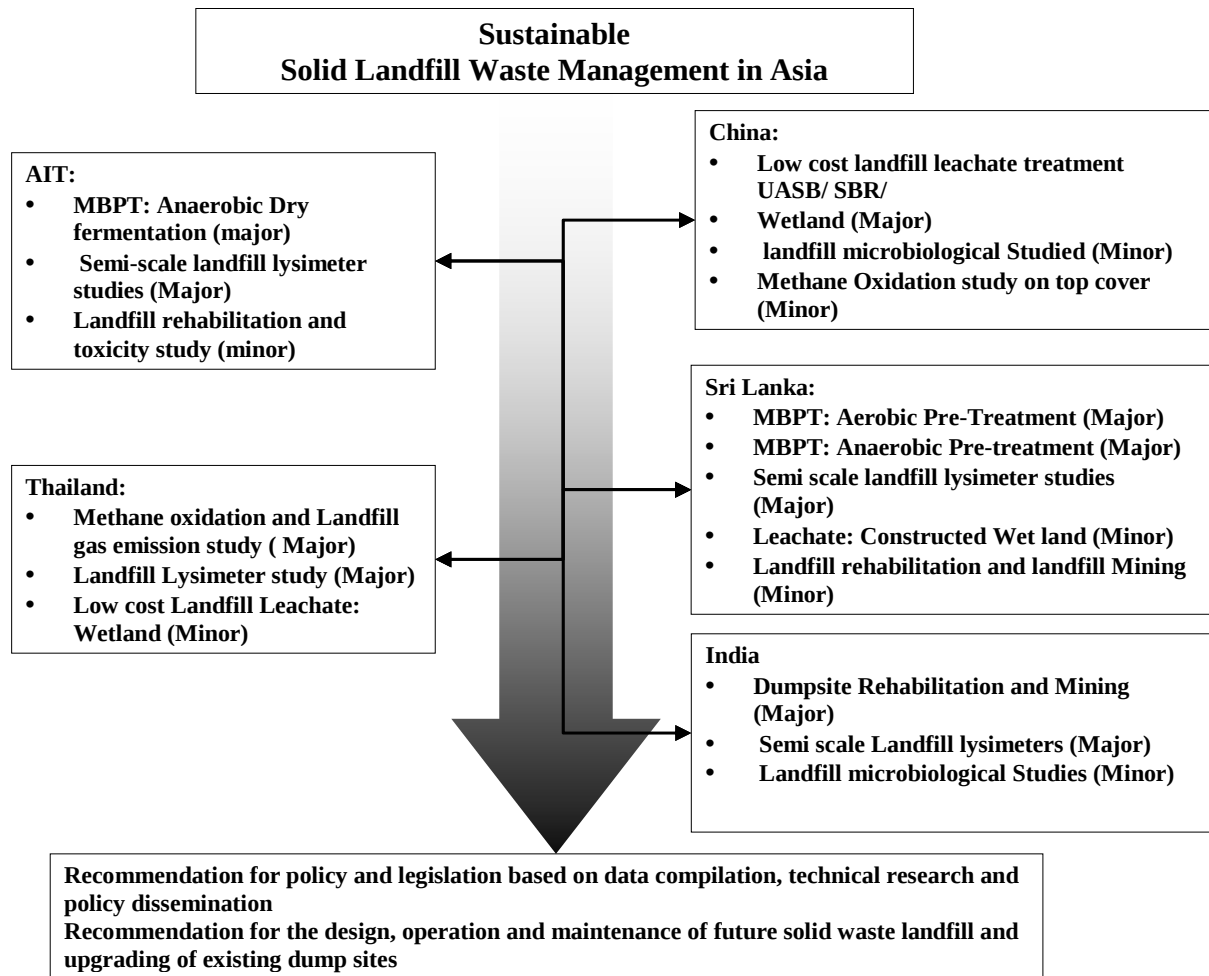


Figure 2. Distribution of Research Studies among the NRIs

3. REALIZATION OF SWLF PROJECT

3.1 Successful Phase I

During the initiation of phase 1 of the project, the research topics were divided among the various NRIs. Sida was very keen to distinctively choose the four NRIs from Asian countries since they can relate more to the present MSW issues in Asia than the rest of the western and eastern countries in the world. Figure 2 displays the distribution of research topics where each study is being investigated by at least two NRIs. Though the same research topic was given to two NRIs, but the investigation approach by each researcher was totally different from each other. By doing so, redundancies of researches are avoided and diversities of studies are explored, which can only be achieved through networking of researches. One example is the research on landfill lysimeter study, which was investigated by AIT and Kasertsart University. Since both institutions were located in Thailand, thus the waste characteristic and climatic influence was known to be similar. However, the study approach of Kasertsart University was on bioreactor simulation of landfill lysimeter where recirculation of leachate into the system was done. On the other hand, AIT simulated an open dump lysimeter study (Figure 3) that investigated the actual degradation of waste in dumpsites in terms of leachate generation,



Figure3. Lysimeter studies at AIT, Thailand

leachate composition, landfill settlement, and other parameters. Furthermore, AIT also tried to study the effect of different top cover application in the landfill lysimeter.

Aside from the technical research, the project conducts national conferences / workshops annually to update the NRIs of their respective results. ARRPET is organizing one annual review workshop, which is usually held in AIT for NRIs to meet and discuss the outcomes of their researches. In this way, exchange of ideas is viewed for the improvement of the research and also a way to check the research direction if it is still in line with the project objectives. Swedish experts from University of Kalmar progressively review the technical reports and provide valuable suggestions for the improvement of the research. This approach offers a chance for a third party outside the core researchers to evaluate the progress of their studies.

Apart from the annual review workshops, national conferences are also organized by NRIs in their respective country where the government agencies, policy makers, industries, and private sectors are invited to attend. However, the targeted audiences of these particular workshops are policy maker and relevant government agencies to disseminate the findings based on the technical research, which could make an impact to policy changes and implementations of the researches. All involving NRIs were requested to give a presentation on the outcomes of their studies in the conference. This is also an advantage, as the addressees would be given an opportunity to be expose to regional experts and acquire useful knowledge and skill that could help the country's MSW management issues.

At the end of phase I, the SWLF project was able to publish reports, journals, and international conference papers based on the collective researches conducted by the NRIs. "Municipal solid waste management in Asia", AIT publications (2004), ISBN: 974-417-258-1; "Landfill management in Asia – notions about future approaches to appropriate and sustainable solutions", Ninth International Waste Management and Landfill Symposium (2003), Sardinia, Italy; "Influence of tropical seasonal variations on landfill characteristics – results from lysimeter studies", accepted for Waste Management journal (April 2005); are some examples of project publications. The project is channeling its objectives globally by sharing its technical research results, which is made available in journal publications and internet websites (<http://www.serd.ait.ac.th/sidaSWM/index.htm>).

3.2 Progressing Phase II

Because of the success of phase-I, Sida extended the ARRPET project for four more years to conduct the research with the same team of NRIs. With the continuation of the project, the networking relationships between the NRIs have been reinforced. Most of the technical researches are extension of phase I studies. As phase-I focused on the in-depth pilot scale study of MSW landfill management, phase II will take the initiative to develop country specific case studies relevant to MSW landfilling and management. It will include application of the pilot scale landfill simulation results into big scale municipal dumpsites. In India, Anna University has already proposed to Chennai local government for the rehabilitation of its municipal dumpsites by an integrated approach of composting the waste before landfill. Figure 4 shows the pilot scale landfill mining research conducted at Kodungaiyur dumpsite, Tamil Nadu, India. In Sri Lanka, NRI has been conducting pretreatment of MSW research on pilot scale composting research using Inclined Step Grate system (Figure 5).



Figure 4. View of the augur sampling at Kodungaiyur dumpsite, Tamil Nadu, India



Figure 5. View of the pilot scale Inclined Step Grate composting, Peradeniya, Sri Lanka

Public awareness and their initiative makes a great difference in the overall generation and management of MSW, apart from conducting workshops and training programs to enhance the capacity building, teaching materials, laboratory manuals, design criteria for landfill operation and other related educational tools will also be developed jointly. At present, the proposal has been approved and has been gradually implemented. With this trend of the SWLF project in phase-II, more productive results and fruitful networking interactions will be expected in the coming years.

4. CONCLUSIONS

The critical environmental problems on solid waste landfill management in Asia were identified. The importance of Asian Regional partnership was realized and national scientists expert on this field were chosen. The ARRPET project on Sustainable Solid Waste Landfill Management (SWLF), which is funded by the Swedish International Development Cooperation Agency (Sida) has successfully fulfilled the phase 1 of the project and has carried on its phase 2 up to the present. As municipal solid waste disposal problems prevails in most of the Asian developing countries, the project focuses on providing sufficient tools for the government and policy makers in drafting useful standards to sustain the country's solid waste management issues. Four National Research Institutes (NRI) (India, China, Sri Lanka and Thailand), and AIT has jointly performed the technical researches under the supervision of Swedish partners. A group of research topics were divided among the four NRIs with each research topic investigated by at least two institutions. This has provided a network of researchers working as a team in obtaining the project objectives. With this exceptional networking approach, it has avoided competition among the researchers, maximized resources; efficiently use the expertise of investigators; and faster generation of results needed to achieve the goal of the project.

ACKNOWLEDGEMENTS

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Asian Regional Research Programme on Sustainable Solid Waste Landfill Management in Asia



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Presentation Overview

- ✓ Significance of SWLF Mgt
- ✓ Network of Research Team
- ✓ Phase-I outcome
- ✓ Phase-II Focus
- ✓ Conclusion



Common Features in Asia: Solid Waste

- ✓ Open dumping / open burning is very common practice
- ✓ No proper cover / liner system used
- ✓ No leachate collection or gas collection system available
- ✓ Inadequate experience in Engineered landfill applications
- ✓ Poor in technical performance and economically not viable solutions

Landfill in Thailand



Burning dump site in Lao PDR



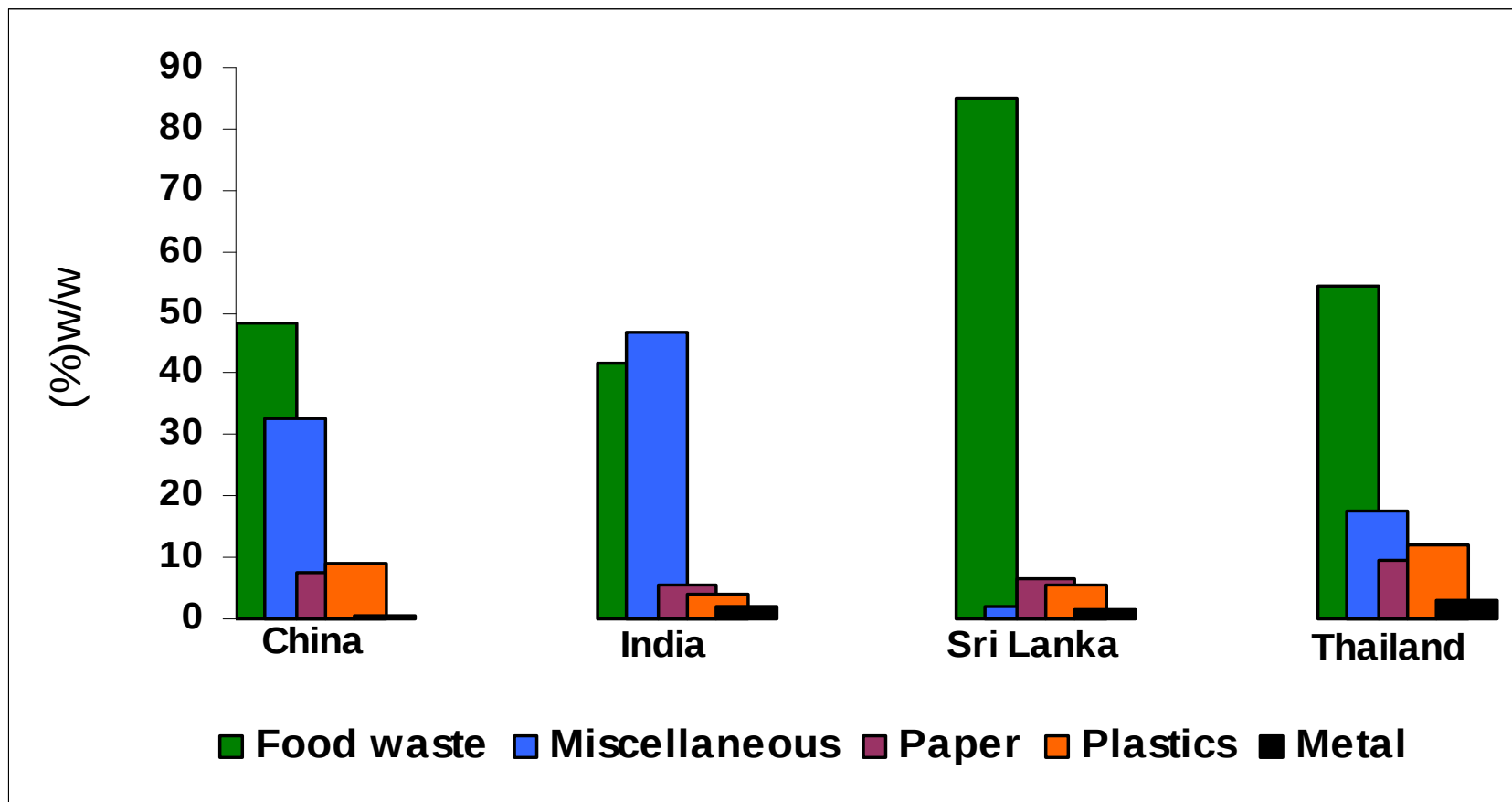
Failures of Sanitary/Engineered Landfill in Thailand?



Common Practices in Asia

- ✓ Similar climatic influences
 - tropical climate
- ✓ Same social/cultural practices
 - More than 50% food waste
 - Moisture content is very high
 - More waste is recycled internally
- ✓ Lack of fund source for MSW landfill mgt
- ✓ Lack of technical solution for proper care
- ✓ Lack of political willingness

Waste Composition



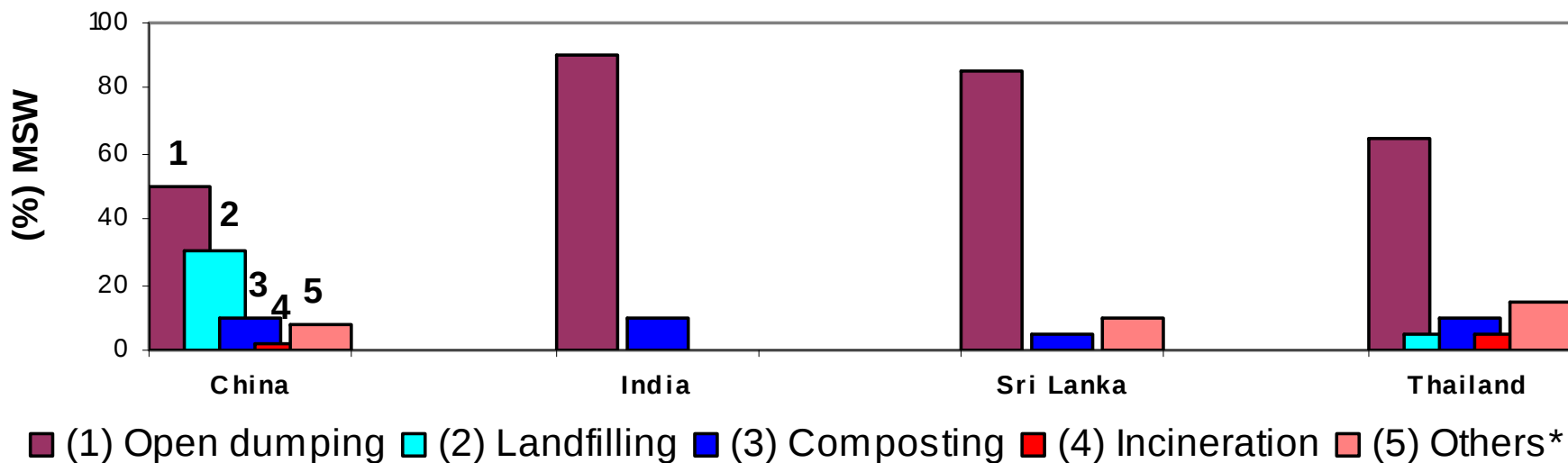
Comparison of organic and inorganic components in the MSW from the study countries

Disposal

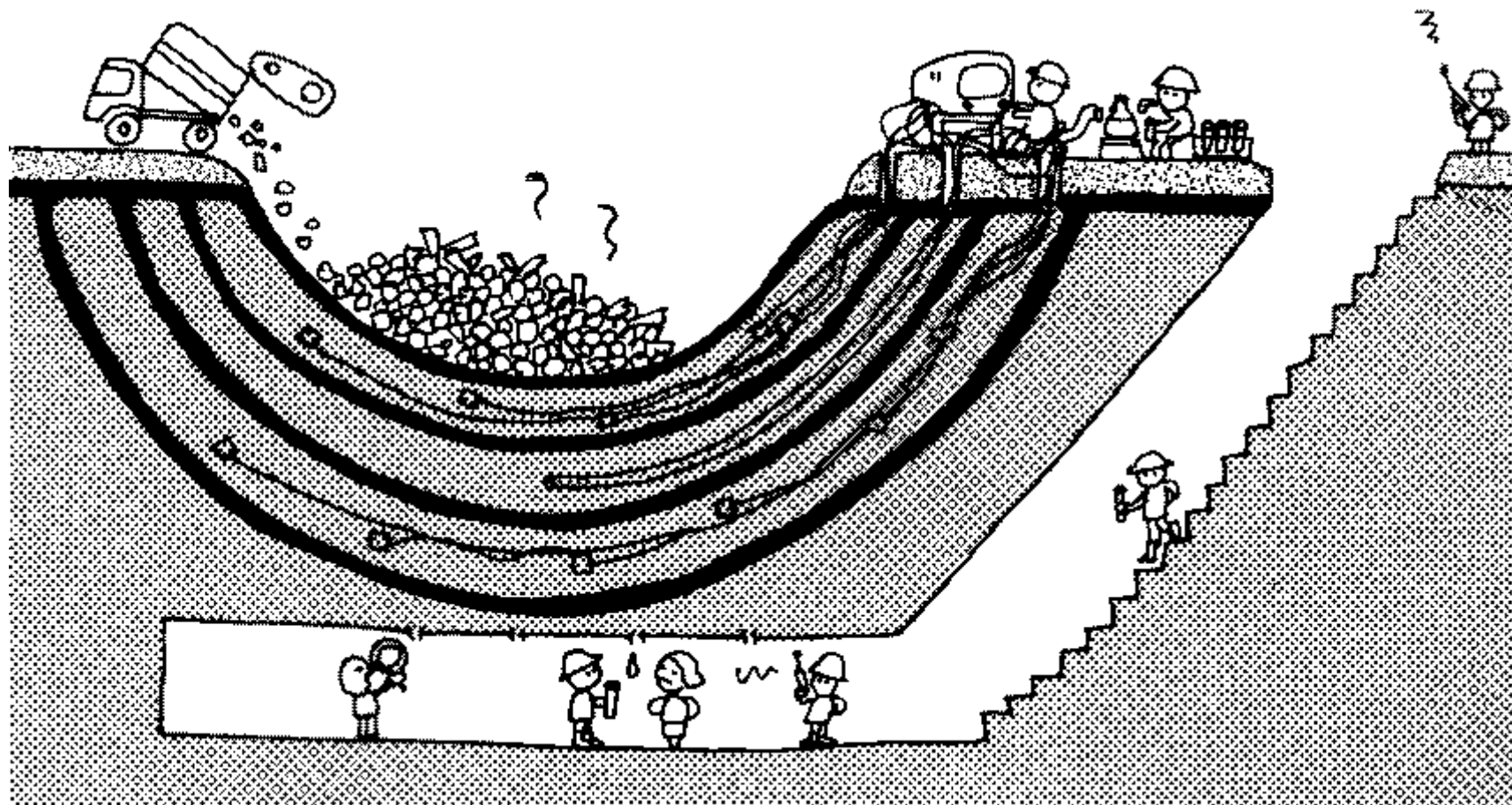
Open dumping: The most prevalent mode of disposal

China = 50%; India = 90%; Sri Lanka = 85% and Thailand = 65%

MSW disposal methods practised in Study Countries



Why Landfill Research?



Why Regional Research Networks

“...regionally focused environmental research and assessments are developed to complement global scale research and transform its advances into usable information for decision making at spatial scales. This will require building the necessary resource base, as well as new partnerships between the relevant sciences and the public and private sectors.”

The Science of Regional and Global Change: Putting Knowledge to Work (NRC, 2001)

- ✓ Integrates researchers from a variety of disciplines to more fully understand the selected research theme
- ✓ Possible South-South cooperation
- ✓ Stimulate creativity and innovative solutions
- ✓ Feasible locally adoptable and economically feasible solution
- ✓ Better understanding of the local problems and utilization of representative from National Institutes in the region



Research Group

**Coordination: AIT
NRIs**

Swedish Expert
Prof. William Hogland
Environmental Engineering
Department of Technology
University of Kalmar
Sweden



India
Anna University

Sri Lanka
University
of
Peradeniya

China
Tongji University

Thailand
Kasetsart University

Project Mission

- ✓ Enhancement of solid waste disposal practices and landfill technology for efficient and effective solid waste landfill management in the Asian region.

Research Objectives

Technology Aspects

- ✓ Identification and development of sustainable, environmentally sound and cost effective solid waste treatment and disposal technologies.

Networking among NRIs

- ✓ Compilation of existing practices of solid waste management and basic information about solid waste organization (case Studies), preparation of training materials, lecture notes, workshop and training programs, workshops and policy dissemination

Policy and Institutional Aspects

- ✓ Identification of gaps and recommendation in policy and legislation based on data compilation, technical research and policy dissemination.

Main Research Topics

- ✓ Pretreatment of solid waste
- ✓ Operation of landfills for a controlled and enhanced degradation
- ✓ Management and reduction of landfill gas and leachate emissions
- ✓ Rehabilitation of dump sites
 - Refuse Derived Fuel
 - Waste Electrical and Electronic Equipment

Sustainable Solid Waste Landfill Management in Asia

AIT:

- MBPT: Anaerobic Dry fermentation (Major)
- Semi-scale landfill lysimeter studies (Major)
- Landfill rehabilitation and toxicity study (minor)

Thailand:

- Methane oxidation and Landfill gas emission study (Major)
- Landfill Lysimeter study (Major)
- Low cost Landfill Leachate: Wetland (Minor)

China:

- Low cost landfill leachate treatment UASB / SBR /
- Wetland (Major)
- Landfill microbiological studies (Minor)
- Methane Oxidation study on top cover (Minor)

Sri Lanka:

- MBPT: Aerobic Pre-Treatment (Major)
- MBPT: Anaerobic Pre-treatment (Major)
- Semi scale landfill lysimeter studies (Major)
- Leachate: Constructed Wetland (Minor)
- Landfill rehabilitation and landfill Mining (Minor)

India

- Dumpsite Rehabilitation and Mining (Major)
- Semi scale Landfill lysimeters (Major)
- Landfill microbiological Studies (Minor)

Recommendation for policy and legislation based on data compilation, technical research and policy dissemination
Recommendation for the design, operation and maintenance of future solid waste landfill and upgrading of existing dumpsites

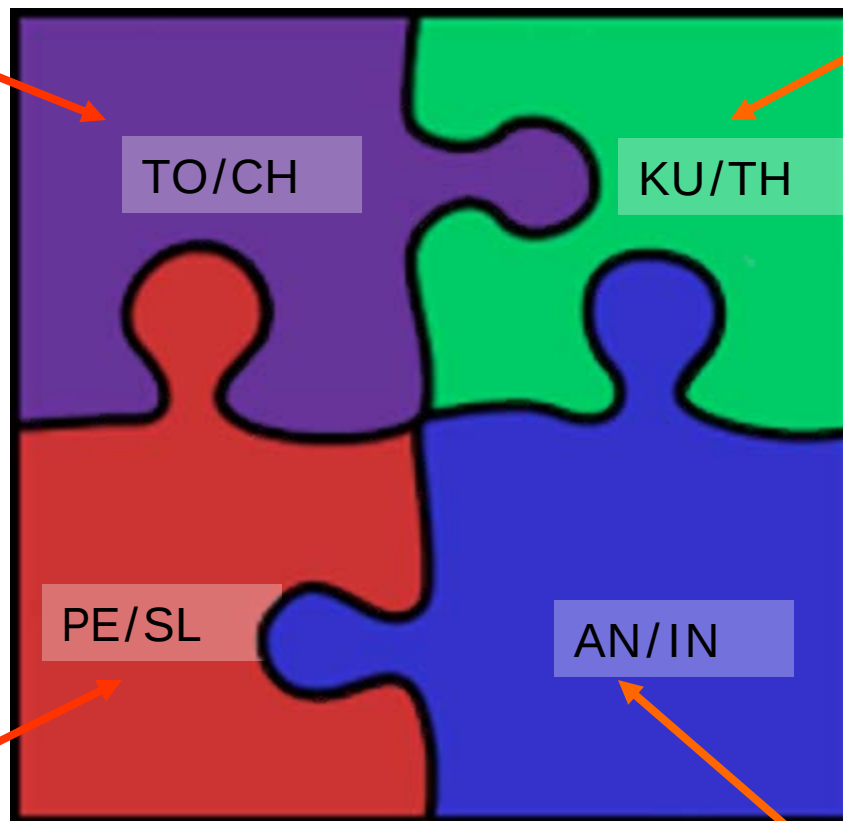
Networking

- ✓ Different NRIs have different competences
- ✓ Integrating such competence for a regional research through networking
- ✓ Allow the NRIS to conduct individual research
- ✓ Share / joint conduction of research on common activities

Sustainable Landfilling Technologies

Landfill leachate treatment

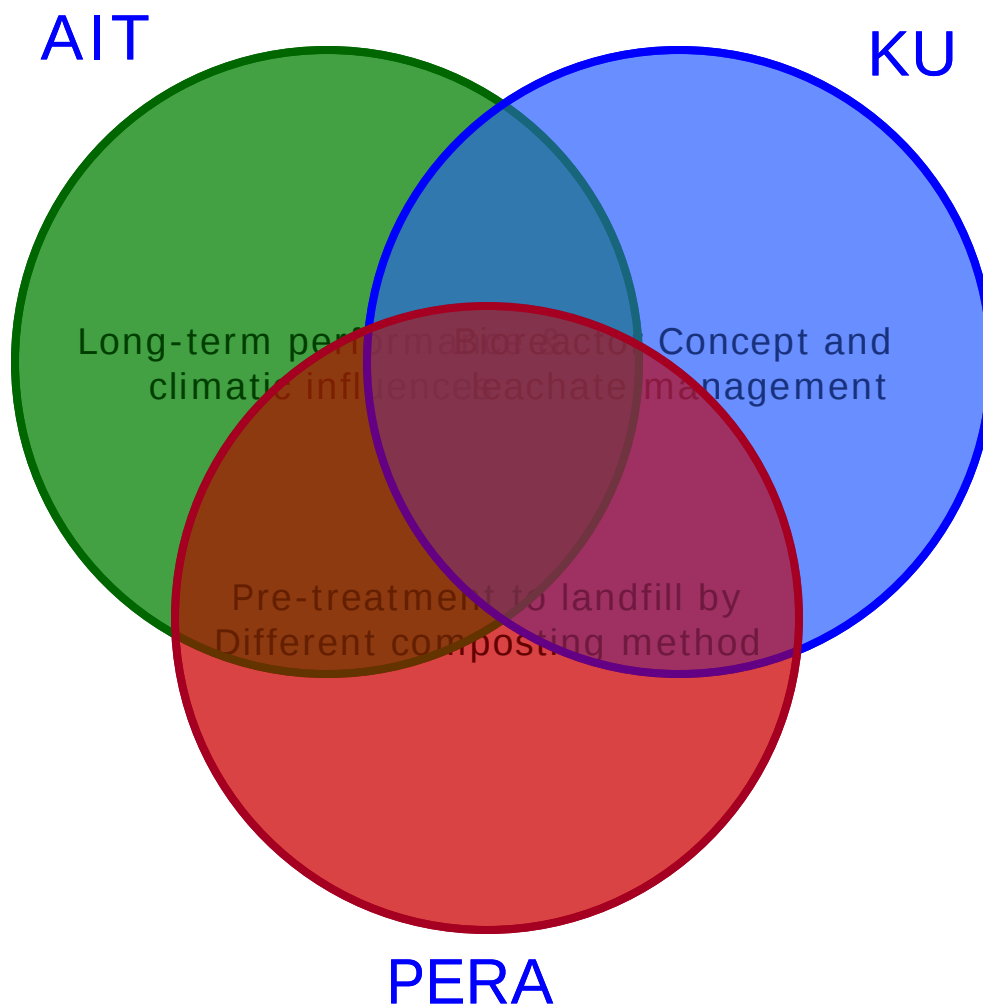
Methane emission and oxidation studies in the cover soil



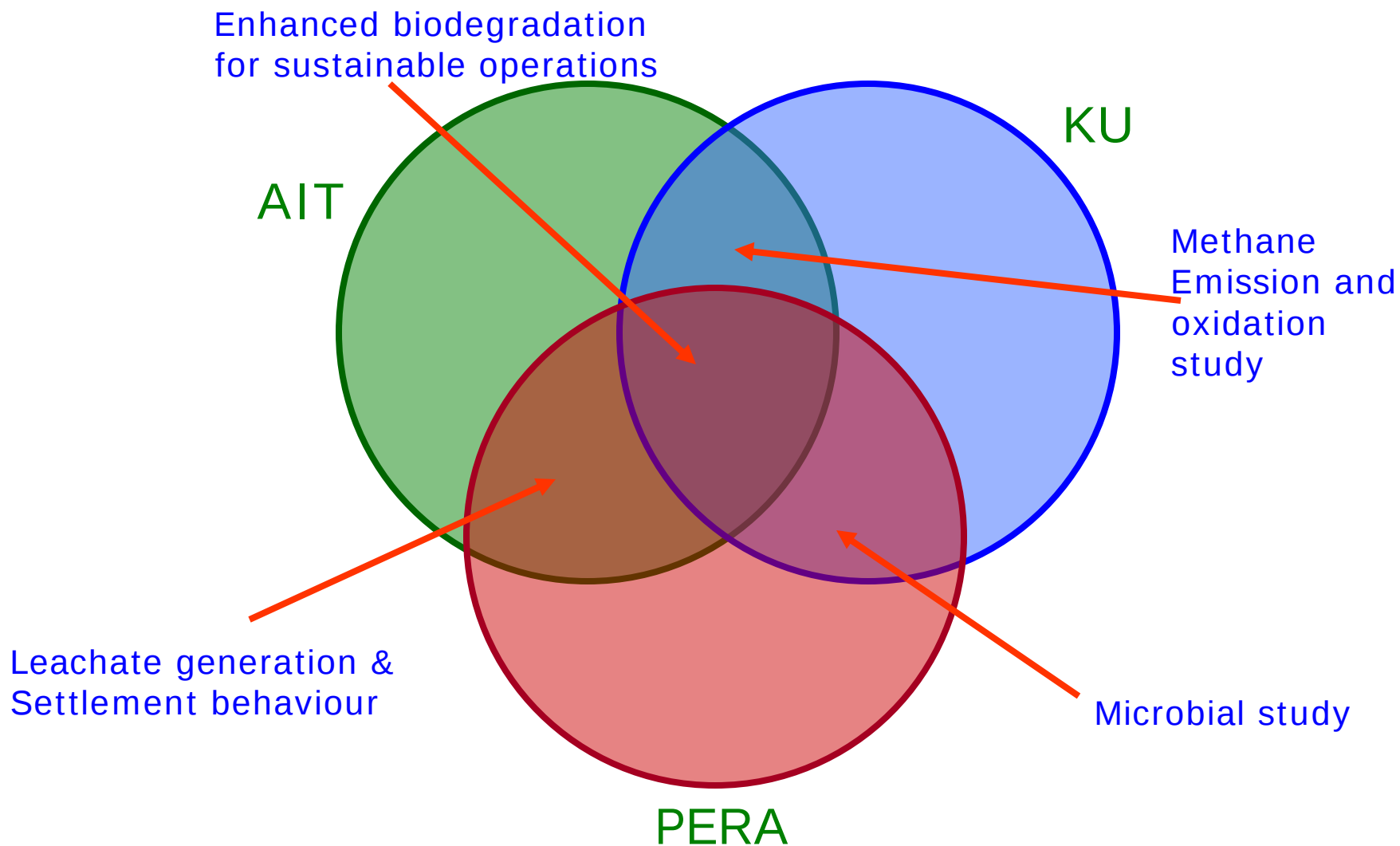
Landfill pretreatment technologies

Landfill rehabilitation and mining

Landfill Lysimeter Simulation



Landfill Lysimeter Simulation



Research Activities-Phase I



SBR Leachate treatment-China



Landfill mining & rehabilitation study-India



Pretreatment by composting- Sri Lanka



**Dumpsite mining and toxicity study-
Thailand**



**Combined anaerobic digestion-
Thailand**



Methane Oxidation study -Thailand

Publications and Others

Indian NRI received the best paper award- Sardinia 2003 "**Kirton Curl**" award for Best Waste Management paper in developing countries

SARDINIA 2003 - "Kirton Curl" award

Books/Reports- Joint Publications

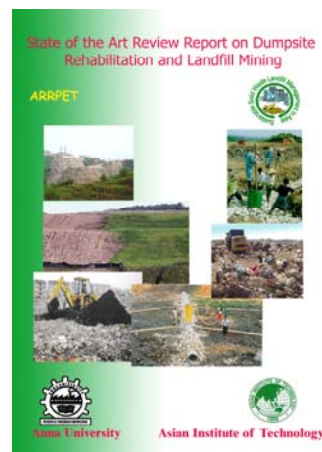
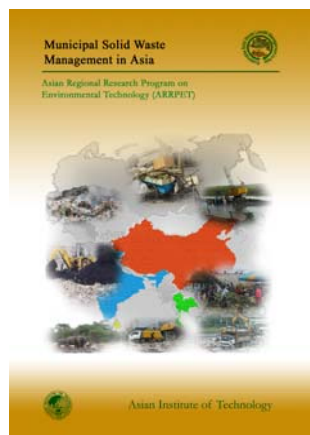
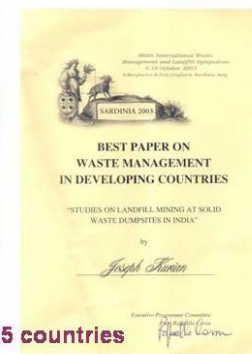
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October 6-10, 2003
About 400 papers
About 900 delegates from 65 countries
5 papers from AIT/NRIs



Impact of the Project

Capacity building: NRIs have not only developed their own research capacity and institution facilities but are also recognized as the national solid waste experts:

- ✓ NRI India: Recognition of the competence on landfill rehabilitation and landfill mining by the cooperation of Chennai and initiation of dumpsite rehabilitation projects;
- ✓ NRI Sri Lanka: PI has been appointed to assist the court on sorting out the solid waste related problems and provide solutions;
- ✓ NRI China: Designed and implemented the landfill leachate treatment plant in Shanghai based on the experimental outcomes.

Public awareness: Apart from the technical publications, NRIs have given interviews and published many popular articles and other public media based on the research findings



The Hindu from India

Corporation of Chennai's initiative to dumpsite rehabilitation
State level Committee for SWM



Major Focus- Phase II

- ✓ Scale up of experimental units: Lab scale → pilot scale
- ✓ New minor research topics
 - WEEE
 - RDF
 - Construction waste
 - Medical waste
- ✓ Networking
 - Text books, development of country specific case studies teaching materials, lab manuals, landfill design and operational manuals
 - Dissemination workshops, national / regional / international conferences
 - Websites, roadmap CD and other public information dissemination

Conclusion

- ✓ Sustainable solid waste landfill management technologies for Asia
- ✓ Locally adoptable techniques
- ✓ Cost effective and adoptable solutions
- ✓ Capacity mobilization, Policy suggestion and dissemination seminars
- ✓ Academic tools development for Asian context: Books, laboratory & operation manuals, teaching materials etc

http://www.faculty.ait.ac.th/visu/main_page.htm