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Issues for better implementation of cleaner production in Asian small and medium industries

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Abstract

The Cleaner Production (CP) approach has brought gains to large energy intensive industries, which have the capital, technical know-how and the organisational capacity for implementing new and innovative techniques. However, the introduction and implementation of CP in Small and Medium Industries (SMI) needs to be done based on an integrated approach of seven focal areas. These are: integrated pollution prevention and control, interaction between energy, environment and climate, development of technology based benchmarking, identification and co-ordination of various internal and external actors, capacity building, technology development and transfer, and financial packaging. These issues have been shown to be important to ensure that CP introduction in SMIs succeeds.

Keywords: Small and medium scale industries; Cleaner production; Pollution prevention; Energy efficiency; Bench marking

1. Introduction

Cleaner Production (CP) is the latest integrated approach in handling wastes and pollutants in industries. Before the idea of sustainable development became an integral part of every production system, environmental protection was carried out through end-of-pipe (EOP) technologies. Today, the relevance and importance of the CP issues has been well understood and documented through many case studies [1]. Though these CP experiences mainly dealt with waste reduction and elimination of related activities, it is in fact a multidimensional activity, encompassing environmental pollution, energy and climate change related issues. At present, as the focus is principally on environmental pollution, attention has been devoted to developing and applying cleaner production methods in activities contributing to these pollution problems. The largest contributor to emission and environmental pollution has been the large energy consumers, namely, the power plants and the high energy intensive industrial sector. Considering, that the industrial sector is a major contributor to the local, regional and global pollution problems, and is expected to be so in future, the CP issues of this sector need to be addressed on a priority basis.

In the industrial sector, large industries have acted on this recent concept of CP and reaped the rewards of environmental protection and financial growth [2]. A notable credit is also due to the recent introduction of the ISO 14000-based Environmental Management Systems. This progress is reflected through the continuous accumulation of CP case studies, for example, through the UNEP-ICPIC and the other related databases. A significant momentum on the application of CP concept has been generated in large industries and during the next decade these could be expected to proliferate even without any notable external assistance.

However, the application of the CP concept in Small and Medium Industries (SMI) has often not been substantial. For example, in Thailand, fourteen different funding agencies have set-up demonstration projects in various SMI sectors since 1989 [3]. Although, these industries have clearly demonstrated the technical and financial viability (in terms of low pay back period), these demonstration projects often failed to rise to the original expectation of the mutiplication effects of the

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CP concepts in SMI sub-sectors. The distinct characteristics of SMIs, such as lack of resources and skilled manpower, and unwillingness to take high risk could have been the major hurdle for the adoption of the CP concept. From these experiences, and considering the growth and proliferation of these industries in Asia, it is clear that during the next decades the CP application and research need to be concentrated mainly in the SMI sector. The inherent characteristics of SMIs necessitate a different approach for the introduction of CP concepts as compared to the large industries. This approach should consider all aspects of the SMIs, which when considered holistically will provide for a sustained growth of this sector.

This paper identifies and describes seven focal areas specific to the SMI sector that need to be addressed carefully. Clear examples are provided to illustrate the relevance of these issues.

2. Small and medium industries (SMIs) in Asia

Small and Medium Industries (SMIs) generally account for over 85% of the total number of manufacturing establishments in Asia and make a significant contribution to its economic development, in addition to income and employment generation. In Indonesia, for example, 88% of the total enterprises are small scale businesses and account for 32% of employment in the manufacturing sector [4].

SMIs are being promoted in developing countries as they provide a seed bed for economic growth, stimulate indigenous entrepreneurship, lead to development in rural and semi urban areas, etc [5]. Furthermore, SMIs serve as a training center for developing skills of industrial workers and entrepreneurs. Asian SMIs are more often owned and managed by family members, usually limited to confined activities (due to lack of resources and skilled manpower), adopt a simple management structure and few administrative activities, do not undertake high risk jobs, and are usually involved in the subcontracting market requiring short gestation periods [6].

These industries are characterised by the low level of energy efficiency and the high level of pollution due to:

- Employment of old and inefficient technologies and lack of information on new energy efficient and environmentally sound technologies.
- Poor or absence of waste disposal and treatment systems. More profit-oriented than environment-consciousness.
- Poor industrial infrastructures.
- Existence of technical, economic, informational, social and institutional barriers to the adoption and implementation of environmentally sound technologies.

Therefore, especially in terms of energy use and environment consciousness, SMIs are not only less energy efficient, but also generate high pollution contributing significantly to local and regional pollution. Table 1 illustrates some case studies carried out in the textile sector in CP related activities. It can be seen that though energy and environmental issues have been studied together in some cases, this is not true for a majority of factories, especially from the Asian countries. It is interesting to note that CP activities on energy and pollution have been considered in the developed economies rather than the developing countries, indicating that in most Asian SMIs, a holistic approach to CP should be followed. This clearly demonstrates that though CP promotes both pollution prevention and energy conservation holistically, in practice it is usually not the case.

3. Future direction of cleaner production in Asia-Pacific SMIs

Considering the importance of SMIs in the developing countries and its very nature vis-a-vis large industries, the adoption of CP techniques in SMIs becomes highly relevant for combating pollution and reducing energy use. Implementation of CP techniques calls for a holistic approach (Fig. 1), which is encompassed by seven areas highlighted in the following sections:

3.1. Promotion of integrated pollution prevention and control (IPPC)

CP demonstration projects usually emphasised reducing the pollution at the source and paying little attention to pollution control aspects. While the application of CP approaches significantly reduces the pollution load, a certain amount of pollution load may still need to be handled. Therefore, an integrated approach combining both end-of-the pipe approaches and CP philosophy need to be developed. For example, electroplating is one of the growing small-scale (back yard-owner run) businesses in Asia. These units generate significant toxic wastewater containing heavy metals and organic solvents. In Bangkok alone, there exist more than 300 of these back-yard small captive electroplaters, who generate around 500 m^3/day of toxic effluents, discharging directly into the city sewerage channels. The past experiences with these type of electroplaters have demonstrated that 60–80% of the toxic effluents could be reduced by applying simple pollution prevention techniques [15]. For these projects, which emphasised reduction of toxic effluent through CP promotional activities, practically no attention was paid for the handling of the final reduced volume of toxic wastes, which were continued to be discharged to the city sewers. In these type of SMIs, one option could be that pollution

Table 1
Selected cleaner production demonstration studies of energy and environmental issues in textile industry

Case studies	Environmental issues/technology	Energy issues/technology
Thailand		
Pattaya Printing and Dyeing Co. Ltd [7]	Advanced computerized color matching system. Spectrophotometer for color Matching	
Thana Paisal R.O.P [7]	Caustic soda controller	
Sinsaeene Co. Ltd [7]		Steam piping and insulation and recovery of heat from process water using heat exchanger
Chieng Sang Industry Co Ltd [8]	Installation of EVAC vacuum suction system and computerized spectrophotometer. Condensate cooling and water recovery—pay back period: 3.5 yrs	—Fuel saving—3%
India		
Century Textiles and Industries Ltd [9]	Reduction of sulphide in effluent from sulphur black dyeing	
Binny Textile Mills [14]	Reuse of wastewater from the dyeing and finishing department for quenching ash	
Indonesia		
P.T. Mulia Knitting Factory [10]	Dye substitution with high affinity (90%) dyes—Savings: 736–983 US$/month	
Argo Pantes [10]	Caustic soda recovery—Reduction of production cost by 375,886/year	
Brazil		
Fiacao Tecelagem Sao Jose Planr in Braheena, Minas Gerais [11]	Process optimization, dye-house automation, and color kitchen automation. Enzymatic bleach cleanup in cotton dyeing	5–10% energy saving
Denmark		
SBU I/Textile Group [12], pp. 10–11	Enzymatic bleach cleanup in cotton dyeing	—Energy conservation 2780 GJ, —Reduction in Natural gas consumption 70800 m^3/yr
Novotex A.S [13]	Use of water soluble dyes. Hydrogen peroxide bleaching. Enclosed high pressure jet machines	
Chile		
Hilados y Tejidors Garib S.A. (Hitega) [12], pp 6–7	Recycling of cone-dye cooling water. Recycling of air conditioning system water. Improving softener system in dyeing	
Canada		
Dominion Textiles Inc [14]	Recycling spent nylon hosiery dye baths—Pay back period: less than 3 years	—57% energy saving
Germany		
The Institute of Textile Research and Chemical Engineering [12], pp. 12–13	A removal of sizing agent by Ultrafiltraion—pay back period: 8–18 months	
USA		
Textile Bleaching at Du Pont [14]	Counterflow bleach washers to the caustic washers. Decrease water flow by 5 gal/min at caustic washers	—Energy saving 2,600 lb/steam, —Reduction of water temperature by 10°F. —Cut energy needs by 250 lb/hour steam
Ellen Knitting Mills [14]		Heat recovery from dye bath water by heat exchanger. —Saving: 200,000 litres of oil/year

control techniques could be economically implemented through a *"consortium based"* approach where all the final reduced volume of the toxic effluents could be collected and treated.

3.2. SMI energy use and its impacts on environment and climate

Global Warming and Climate Changes issues will have a dominant effect on the industrial practices in the coming decades. Furthermore, the SMIs pollution on the local neighbourhood environment (land, water and air) is increasing the concerns of the local authorities. Energy use (type and quantity) and technologies (environmentally friendly and energy efficient) have to be considered along with the treatment of pollutants and not as three distinct and separate areas to be tackled independently. A UNIDO [11] study notes that even though the emissions in 2050 at "business as usual" scenarios of developing countries will be less than half as compared to developed countries on a per capita basis, the green house gas (GHG) emission from the industrial sector is likely to be very robust and be centred almost entirely in developing nations. This indicates that to significantly reduce GHG emission, opportunities for increasing energy efficiencies and use of renewable energy in the

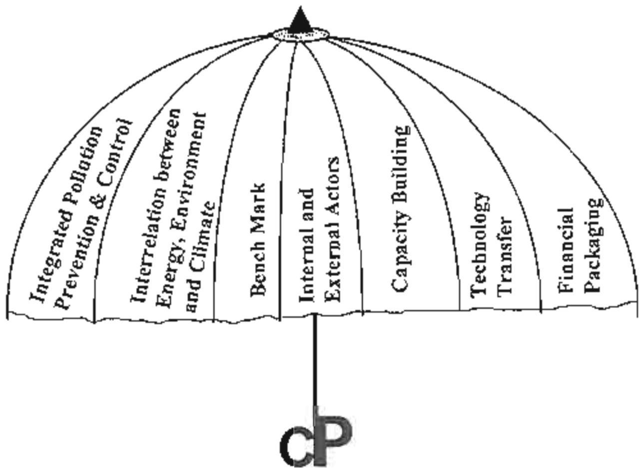

Fig. 1. Seven focal areas of cleaner production.

industrial sector of developing countries can not be ignored.

Table 2 gives the results of a recent study on energy use and CO_2 emissions from selected small and medium industries in Indonesia and Thailand. The specific fuel consumption, specific electricity consumption and the specific CO_2 emission based on fuel (direct CO_2 emission) and electricity (indirect CO_2 emission) are presented based on energy audits conducted in these factories. As the CO_2 emission is primarily dependent on the energy use (fuel and electricity), the relationship between energy use and pollution can be tackled by considering the energy efficiency options seriously, when resolving pollution related problems.

This highlights the importance of looking at an industrial process not only in terms of reducing pollution, but also in terms of energy consumption, which also contributes to pollution generation. The processes and equipment should be energy efficient and environmentally friendly.

3.3. Development of benchmarking

Both energy and environmental issues for the SMIs in the developing countries lack the benchmarks for identifying and defining the reduction goals. The information available is based on the industrialised countries' technologies. Therefore, there is a definite necessity to develop either industry, technology or region based energy and environment benchmarking, specially suitable for the SMIs, which could be an important promotional tool for CP in SMIs. Development of such benchmarks will need a close collaboration among policy makers, industrial associations and equipment manufacturers. The process of bench marking should therefore be a regular process and would help in improving the efficiency of processes and reducing pollution at the various stages in an industry.

Table 3 presents a typical benchmarking for textile-

Table 3
Typical process efficiency benchmarks for the dyeing process [17]

Dyeing machine	Water consumption (Gal)	Typical liquor ratio liquor/good at the time of dye application
Continuous	20	1:1
Black	28	17:1
Jet	24	12:1
Jig	12	5:1
Beam	20	10:1
Package	22	10:1
Paddle	35	40:1
Stock	20	12:1
Skein	30	17:1

Table 2
Energy use and CO_2 emissions for selected SMIs [16]

Sector	Specific fuel consumption (TJ/000 Ton of product)	Specific annual electricity consumption (MWh_e/000 ton of product)	Specific annual CO_2 emission (ton of CO_2 /000 ton of product)
SMI sector (Indonesia)			
Crude vegetable oil Processing	0.16	171.17	182.32
Palm oil processing	7.07	135.60	665.92
Batik industry (Textile)	84.47	423.22	6092.98
Wood processing	5.99	48.86	236.37
Clay bricks manufacturing	6.08	–	26.35
Basic chemicals of wood and gum production	2.65	–	194.03
SMI sector (Thailand)			
Canned fish Industry	8.35	214.18	815.87
Finished Textile	31.82	1195.81	3451.93
Plywood and wood board	1.02	31.31	26.58
Household plastic	–	1202.85	1021.03
Ceramic products	8.5	2287.36	2476.79
Electrical appliances	5.64	1401.89	1608.64

dyeing processes for various types of dyeing machines used [17]. Here, for example, the quantity of water consumption or liquor to goods ratio for a selected dyeing machine could be compared with the reference benchmark level, and therefore the potential in terms of pollution reduction could be identified.

3.4. *Identification and co-ordination of various internal and external actors*

The successful application of CP requires a careful study of the various actors in the SMIs set up. Fig. 2 presents the various external and internal actors associated within an industry, and the complex web of these inter and intra-relationships were often overlooked or neglected while developing the CP programs. The internal environment of an SMI might consist of actors such as, owner of industry, manager, technocrats and employee. It is important to investigate the interaction between these actors to identify the possible adoption of CP activities within an industry. The issues that need to be reviewed as part of this complex interactions are: ownership, organisational structure, decision making processes and local cultural aspects, funding capabilities, business and marketing strategies, human resources development and motivation by incentives, etc. For example, in the Philippines, the CP promotional activities are largely linked to employee award and bonus schemes. Thus, within an industry, the employees tend to promote or adopt CP activities, since there is a direct benefit to them.

In addition to the internal environment and actors, there exist also a large number of external actors and are presented in Fig. 2. Although, these actors do not directly involved in the operation of a SMI, but the promotion of CP activities are to a large extent influenced by these actors. For example, many regulatory bodies developed and adopted unrealistic standards without considering the financial implications to the SMIs and the national economy. Besides, some Asian industry associations and equipment suppliers promote the CP on one hand, while on the other the pollution control mechanisms still practice the end of pipe treatment approach. Many country level CP programs in SMI sector have been started on the *"bottom-up"* approach by the non-governmental or external funding agencies. However, it is also important to have a *"top down"* commitment from the national policy makers, in order that the concept of CP is embedded into the national industrial development plans. As shown in Fig. 2, one of the goals of the CP during the next decade could be to identify interactions between these various actors so that the internal and external environment will move in the same upward direction, leading to a sustainable industry, which is the goal of CP.

3.5. *Capacity building*

The last decade saw a notable investment in capacity building in the CP area, but most activities were designed and implemented either in an ad-hoc basis or were focused on training the specialists. In order that the

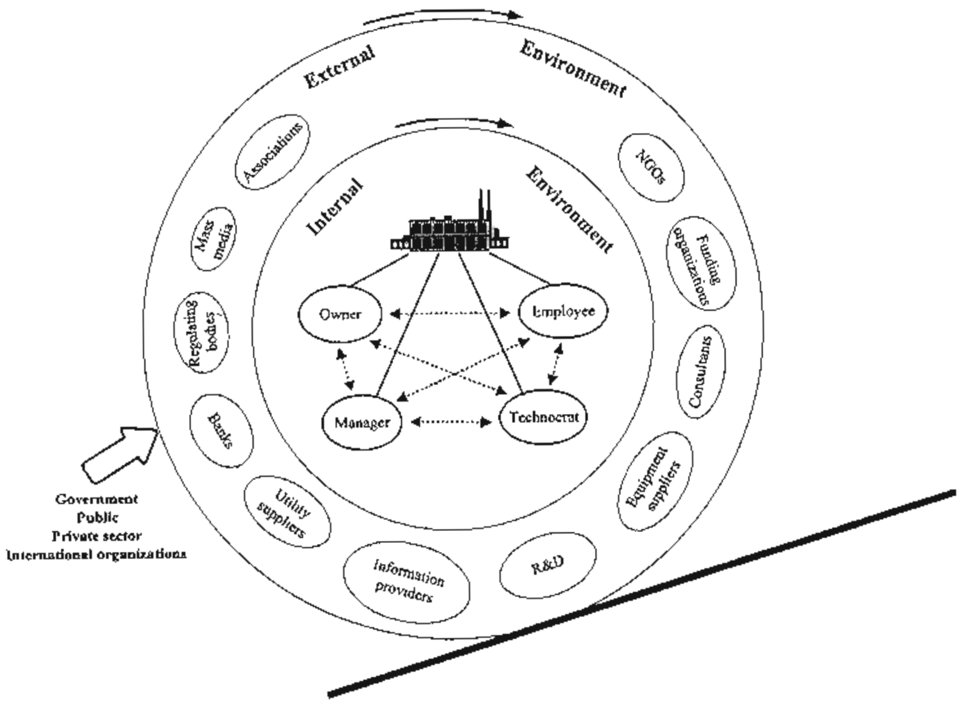

Fig. 2. Industry and its internal and external environment.

real impact of CP be felt in SMIs, capacity building efforts need to reach out to the various actors identified in Fig. 2. As often, SMIs serve as a "Training Center" for developing the skills of industrial workers and entrepreneurs, the training and experience acquired enables them to branch out to other fields. However, the informal—on the job type of training is usually not well organised. Therefore, future CP training activities should not only be limited to the training of specialists, but also should reach out to the various cross sections of future technicians and planners. Examples of such activities are:

1. Introduction of the CP concepts directly in the under graduate engineering curricula or the development of post graduate programs in CP (Example: Australia, Hong Kong, Thailand etc) as well as in the traditional Business Management courses;
2. Hands-on training for technicians;
3. Training of planners at the national level, industrial development organisations and funding agencies.

Unlike large industries, SMI are unable to obtain necessary technical information and know-how. Thus the efforts developed during the last decade by the industrial sector based specialised Working Group of UNEP should continue, but more attention be given to the SMI sector. In addition, analysis of GHG mitigation requires substantial institutional and human resource capabilities and these are often in short supply. Some of the important proposed activities of these sectors could be:

1. Development and dissemination of sector based technology fact sheets and the listing of proven good technologies (Technology Review);
2. Promote an effective electronic information network (Regional or Sub-regional level);
3. Promoting research activities leading to new CP technologies/processes;
4. Developing and monitoring "Environmental Policies" for different sets of SMI categories and industrial parks.

3.6. Technology development and transfer

Sometimes CP in the developing world has seen the adoption of western technologies, which is effective in case of large scale industries. However, this direct application of CP in SMIs which cannot absorb easily the high cost and, moreover the operational nature of the SMI have led to the failure of this approach. Thus, CP promotion should focus more on indeginisation of western technologies to suit local energy, raw material sources and local sustainable environmental policies. The technology transfer could be led by an increased "South-South" interaction for technical collaboration, information sharing and capacity building. Local research and development could be co-ordinated by the organizational groups of individual SMIs for the benefit of that group.

An interesting example on the transfer of technology is the promotion of energy efficiency in the ceramic industry in Thailand [18]. Initiated in 1991, it had two basic options, namely the use of a low mass insulator made of fibre (as compared to the traditional bricks) and the changes to the firing system for better heat distribution and, therefore efficient use of energy. One such demonstration kiln was erected in 1991, and three more kilns were later added to provide on-the job training which was then followed by the preparation of the construction and operation manual. It is now estimated that about 216 such energy efficient kilns are in operation and there are plans for their introduction in other regions of Thailand.

3.7. Financial packaging

Another important aspect to be considered for the promotion of CP in SMIs is related to finance. Mechanisms or agencies with a clear mandate for the promotion of CP related issues at the national level will boost the confidence of SMIs and help in the adoption of CP techniques and practices at a faster pace. For example, the Indian Renewable Energy Development Agency (IREDA) provides loans for renewable energy development and obtains funds from agencies such as GEF, World Bank etc. National level financial mechanisms should be developed to obtain funds for CP activities.

A survey in Thailand found that though one of the important barriers which prevents the industries from using energy efficient technologies is the attitude of factory personnel towards energy efficiencies, the other important barrier is the lack of finance [19]. Many examples of the financial viability of CP programs in industries are documented and are given in terms of energy saving, reduction on water use, other raw materials use and pay back period [12 pp.12–13]. These are also highlighted in Table 1 for a number of case studies. Furthermore, it has been estimated that the energy saving in the ceramic industry is of the order of more than three million kg of LPG/year with a total value of more than US$1.3 million/year (at 1996 rates) [18]. These examples highlight the financial viability of implementing CP (pollution prevention and energy saving) programs in SMI sectors. This also necessitates that bank officials and personnel of financial lending institutions be aware of the nature of CP techniques and its potential in the growth of the industrial economy. Training of bankers [20] could lead to the introduction and development of financial packages for the SMI owners for implementing CP techniques.

Table 4 summarises some of the economic tools proposed and/or adopted to promote CP related activities in

Table 4
Different economic tools used for promotion of cleaner production

Country	Tools used		
	Subsidies	Activities related to EMS	Others
Indonesia	Soft loans and Tax exemptions for installation of treatment facilities focussed toward CP	Encourage Eco Labeling schemes to implement CPDevelopment of environmental fund	Develop award programs for CP
Singapore	Tax Incentives in the form of investment allowances to be given to industries which adopt CPAccelerated Depreciation Scheme for industries having better performance than existing legal discharge limitsGrants to pollution prevention initiatives involving research and development		Environmental Achievement Award for companies following CP methods
Taiwan	Low-interest loans from banksInvestment Tax credit Import Tariff exemptionAccelerated depreciation of waste management equipment	Promotion of ISO 14000 based EMSGreen Design campaignDeveloping Standardized codes of manufacturing practices (Responsible Care Program)	Establishment of National Center for Cleaner Production (NCCP)

some Asian counties. In terms of subsidies, the economic tools used by governments are usually in the form offering low interest loans, allowing for accelerated depreciation, tax exemption etc. Some countries also promote Environmental Management Systems (EMS) by eco-labelling, green design, etc. Besides, environment awards and the establishment of CP centres (national and/or regional) also help in promoting CP.

4. Conclusion

The approach of CP in industries is becoming increasingly important and more so in the SMI sector. This paper underlines the importance of implementing a holistic approach when introducing CP in the SMI sector in Asia. This has been done by highlighting seven areas which encompass the various aspects of the industry for its sustainable growth in the long run. These focal areas need careful consideration for the application of CP techniques specifically relevant to the SMI sector.

References

[1] UNEP/IEO. Cleaner production world wide. United Nations Publications, 1993.

[2] Berkel RV. Cleaner production in Asia: examples of results and their methodological and strategic implications in green productivity—in pursuit of better quality of life. Tokyo, Japan: Asian Productivity Organisation, 1997:195–214.

[3] Thailand Environment Institute. Cleaner technology in Thailand. DANCED cleaner technology promotion project document, Bangkok, Thailand, 1997.

[4] Jin KS, Suh JW. Co-operation in small and medium scale industries in ASEAN. Kuala Lumpur: Asian and Pacific Development Center, 1992.

[5] Nanjudan N. Small and Medium Enterprises: Some basic development issues. J. of Industry and Development 1987;20:1–50.

[6] Asian Productivity Organisation (APO). Development of small and medium industry: four prize-wining essays under the APO. Oshikawa Essay Contest, 1990. Tokyo: APO, 1991.

[7] Cleaner Technology Information Center, Thailand Environment Research Institute. CT demonstration. Newsletter of the Cleaner Technology Information Center Thailand, vol. 3, 1998 10

[8] United Nations Environment Programme, Industry and Environment. Cleaner production in the Asia and Pacific economic region. United Nations Publication, 1994,22.

[9] United Nations Environment Programme, Industry and Environment Programme Activity Centre. Cleaner production worldwide. United Nations Publication, 1993:18–19.

[10] BAPEDAL, Environmental Impact Management Agency. Cleaner production in Indonesia, 1996:3–10

[11] United Nations Industrial Development Organizations. Cleaner industrial production: UNIDO-Funded Demonstration Projects, 1994:2–3.

[12] United Nations Environment Programme, Industry and Environment. Cleaner production worldwide. United Nations Publication, vol. 2, 1995.

[13] United Nations Environment Programme, Industry and Environment Programme Activity Centre. Cleaner production worldwide. United Nations Publication, 1993:8–9

[14] United Nations Environment Programme, Industry and Environment. The textile industry and environment. United Nations Publication, Report No. 16, 1993:85–89.

[15] Visvanathan C, Datar RV. Final report on waste audit for Bangplee Chromium Co Ltd. APO Demonstration Project. Bangkok, Thailand: AIT, 1996.

[16] Architrandi P. GHG Mitigation potential in small industries in Indonesia and Thailand. Unpublished AIT Masters thesis, Energy Program, SERD. Bangkok, Thailand, 1998

[17] Smith B. Pollution Prevention: identification and reduction of

pollution sources in textile wet processing. Department of Textile Chemistry, North Carolina State University, USA, 1992.
[18] Ayman, R. Evaluation of the energy efficient ceramic kiln project in the Northern Region of Thailand. Thai-German Energy Efficiency Project, GTZ. June–November, Bangkok, Thailand, 1996.
[19] Thailand Environmental Institute (TEI). Industrial survey of energy and environmental technology. Bangkok, Thailand, May 1997.
[20] Asian Institute of Technology. Training package on industrial pollution abatement strategies for Sri Lankan project appraisal officers. Environmental Engineering Program, Bangkok, Thailand, April 1995.