THE SCOPE FOR CLEAN PRODUCTION: SOME COMMENTS ON THE TEXTILE INDUSTRY IN THE GREATER DURBAN METROPOLITAN AREA (SOUTH AFRICA)

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1. INTRODUCTION

The Greater Durban Metropolitan Area (GDMA) – the largest conurbation in the province of KwaZulu-Natal, South Africa (see Map in Appendix 1) – has been identified as one of three metropolitan areas in South Africa to be developed in terms of the United Nation’s Local Agenda 21 programme for localised sustainable development.¹

While the GDMA authorities readily acknowledge that the most widely used definition of sustainable development is to be found in the World Commission on Environment and Development (Brundtland) Report of 1987,² it has argued that the Brundtland Report’s approach has limited relevance for less developed countries, especially those where the existing natural capital stock has been degraded to the point where it is below the level required for sustainable development (Pearce, Markandya & Barbier, 1990). Thus a more localised, ‘basic needs’ approach to sustainable development has been adopted, along the lines of the International Council of Local Environmental Initiatives (ICLEI), a United Nations Environmental Programme which emerged from the Agenda 21 process (UNCED, 1993: 233-234). The ICLEI (1993) approach to sustainability places the emphasis upon ‘Development that delivers basic environmental, social and economic services to all residents of a community without threatening the viability of the natural, built and social systems upon which the delivery of these services depends.’

Given the conditions which exist in the GDMA (see Section 3 below), the ICLEI’s definition of sustainable development would appear to have more immediate relevance for the implementation of the Local Agenda 21 programme in the GDMA. Nevertheless, it does not explain how these ‘services’ are to be delivered, nor how the ‘viability’ of the environment is to be maintained. More importantly, it can be argued that both the Brundtland report and the ICLEI have adopted a fragmented approach towards environmental protection. There is a tendency to treat resource usage, pollution and waste management as connected, but diverse, issues, and thereby miss the opportunity to employ a more holistic approach to the treatment of these related problems in industry. A discussion of these issues, with specific commentary on the scope for clean production in the textile industry in the GDMA, forms the substance of this paper.

2. THE ENVIRONMENT AND THE ECONOMY

At its most basic level, the simplest model of the relationship between the environment and the economy is one based on the first law of thermodynamics: the so-called ‘conservation of mass principle’ in terms of which materials extracted from the environment must be returned there in approximately equal mass (Field, 1994: 19-23). Seen in this context, the environment is the source of all natural resources and the repository (or ‘sink’) for all wastes. Therefore, it is not surprising to find that, historically, this model has been described as a ‘black box’: the pursuit of higher rates of economic growth was seen to be harmful to the environment.

¹ At the time of writing, two other South African conurbations - Johannesburg and Cape Town - have also adopted the Local Agenda 21 charter.
² ‘Sustainable development is development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs’ (WCED, 1987: 8).
because it resulted in a greater depletion of natural resources (both renewable and non-renewable) and, of course, it also generated a greater increase in the production of wastes (Dorfman & Dorfman, 1972: 323-329; Cottrell, 1978: 39-41).

Notwithstanding more than two decades of extensive research in environmental economics, which indicates that the relationship between the environment and the economy is highly complex and does not necessarily amount to a ‘black box’, a widely-held view of the cause of modern environmental degradation holds that the fundamental blame lies with the growth of industrialisation. Thus it is often pointed out that during the first three-quarters of this century there occurred a fifty-fold increase in global industrial production which was only made possible by a massive surge in both natural resource usage and its by-product, waste. While it is popular to draw a simple correlation between the growth of industry and environmental degradation, more than twenty-five years ago Commoner (1972: 261-283) argued that it might be more instructive to focus on the technological developments that have underpinned the growth of industry, especially since the Second World War. Commoner’s seminal work revealed that the results of modern industrial technology have been a pronounced displacement of natural products with synthetic ones, of energy-conservative products with energy-intensive ones and of re-usable products with disposable ones. Thus he concluded that the technological thrust of the past half-century has been strongly counter-ecological. This view has received strong support in more recent years from, among others, Perrings (1987) and Duchin & Lange (1994).

A related development has been the emergence – some would argue, re-emergence – of the study of industrial ecology (see Commoner, 1997). Leaving aside the assertion that ‘industrial ecology’ is an oxymoron, Erkman (1997: 1) has argued that there is broad agreement that industrial ecology contains at least three key elements:

- It is a comprehensive, integrated view of all the components of the industrial economy and their relations with the biosphere.
- It emphasises the biophysical substratum of human activities, that is, the complex patterns of material flows within and outside the industrial system, in contrast with current approaches which mostly consider the economy in monetary terms or in terms of energy flows.
- It considers technological dynamics, that is, the long-term evolution of clusters of key technologies as a crucial element for the transition from an unsustainable industrial system to a viable industrial ecosystem.

Fully in line with this approach, there has emerged a growing interest in the concepts of ‘clean production’ and ‘clean technology’ (Van Berkel, Willems and Lafleur, 1997: 21-23). If it is accepted that the major environmental problems associated with industry are excessive natural resource usage (especially of non-renewable resources), inefficient usage within production processes, the pollution that results from these processes and the problems associated with waste disposal, then it is possible to adopt a holistic approach to industrial environmental management through the related concepts of ‘clean production’ and ‘clean technology’. Clean production implies a strategy that is geared towards the adoption of industrial processes which reduce consumption of natural resources, make more efficient use of inputs (including raw materials, energy and water) and also reduce the generation of waste materials. At its broadest level, it implies a fundamental shift in both business practices and consumer behaviour – a rethinking of the relationship between society, economy and the environment. More narrowly conceived, it recognises the central role played by technology in industry, and seeks to promote research and development in, and the ultimate adoption of, ‘clean production’ in industry.

Clean technology – which originated with the Cleaner Production Programme launched by the United Nations Environment Programme in 1990 – has been defined as ‘technology which improves the thermodynamic efficiency of production processes and which substitutes less hazardous processes, products and activities for more harmful ones’ (Jackson, 1991). The methodology underlying this approach is that of life-cycle analysis, wherein all of the impacts involved in producing, consuming and disposing of products are identified. This dynamic approach has informed the research carried out by the International Association for Clean Technology (IACT), which has defined clean technology as:
any environmental measure that is taken to contribute to the closure of the production-product life cycle. This could include the better use of raw materials, new processes, integrated recycling, new product specifications and recycling of waste products as raw materials.\(^3\) In terms of this definition, it is argued that clean technology embraces at least four categories of technological changes: good housekeeping; recycling; process modification; and materials substitution.

These four categories of technological changes are outlined below in order of decreasing ease of implementation:

- Good housekeeping practices involve changes in operating practices with significant potential for cost savings and waste reduction. This element of clean technology is regarded as relatively easy to implement and is usually seen as a low-cost option with a pay-back period of months rather than years.
- Recycling, especially of ‘new’ scrap on site, can be improved by modifying process flows. It has been pointed out, however, that the technologies involved ‘are often quite sophisticated with higher maintenance requirements, therefore necessitating greater technical competence with implications for changes in operating practices and skills training’ (EMG, 1993: 4).
- Process modification geared towards improving material efficiencies and reducing waste materials – a process that is not only costly but requires much more research and development than is presently being undertaken (Jackson, 1991).
- Finally, materials substitution is regarded as the most difficult and costly challenge facing those who favour clean technology. Nevertheless, as an interim measure, it is argued that economic instruments could be used to promote a shift towards the use of more environmentally-friendly materials.

It is generally agreed that the potential for improving environmental performance using the above-mentioned techniques is significant. Indeed, several international studies have demonstrated that materials savings of up to 40% are possible (USEPA, 1996). What remains to be seen is whether the claims made for clean technology can be realised in at least one of the major industrial groups within the GDMA: the textile industry.

3. SOME COMMENTS ON THE EXISTING SITUATION IN THE GDMA

The GDMA comprises virtually the full range of economic activities to be found in the national economy: agriculture (both commercial and subsistent); the second-largest industrial complex in South Africa (dominated by large-scale, capital-intensive enterprises); the financial centre of KwaZulu-Natal; a substantial commercial sector (with a particular focus on retail trade and tourism); an important transport sector (the Port of Durban is the busiest port in Africa); and a well-developed energy industry (although confined to the major urban centres).

The GDMA is also characterised by rapid population growth (with all the attendant demands for health services, educational facilities, housing and jobs); rapid urbanisation (which has placed an enormous strain on social infrastructure in urban and peri-urban areas, especially the need for potable water, affordable housing and basic sewerage); large-scale, formal sector unemployment (estimated to be 33% or more of the economically active population); large-scale underemployment of labour resources (whereby low labour productivity has raised labour costs); and an educational infrastructure that is strained to the limit to meet basic schooling needs and, arguably, is not geared to meet the appropriate educational needs of the region.

Against this background, the outstanding feature of the GDMA’s economy is the dominance of manufacturing. This sector accounted for 35% of the Gross Geographic Product (GGP) of the Durban Functional Region (DFR) in 1990,\(^4\) and a recent study estimated that the

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3 See UNEP (1996a: 5-6) for a valuable discussion of the definition of ‘clean technology’.
4 Prior to 1995, when local government restructuring gave rise to the newly-defined GDMA, the area incorporating the city of Durban and its environs was more broadly defined as the Durban
manufacturing sector’s contribution to GGP has grown to approximately 40% by 1994 (Hindson, King & Peart, 1996). Industry in the GDMA comprises the seven major manufacturing groups identified in Table 1 below. (The data contained in Table 1 are dated and should be treated with caution, but in the absence of more reliable, recent data, they do provide an indication of relative size.) Of these, chemicals, textiles & clothing, paper and fabricated metal products/motor vehicles warrant special consideration. The chemicals industry is the largest in terms of its percentage contribution to manufacturing output in the DFR, although it is less significance as an employer of labour. The related industries of textiles & clothing rank third (after Food), but constitute the most important group in terms of employment. Paper and motor vehicle manufacture also make significant contributions. (With regard to the latter, the Toyota plant located at Prospecton, south of Durban, is the largest vehicle manufacturer in South Africa.)

Table 1: Major Manufacturing Groups in the DFR (1990)

<table>
<thead>
<tr>
<th>Manufacturing Group</th>
<th>% Contribution to Total Manufacturing</th>
<th>% Contribution to Total Industrial Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>17.1</td>
<td>12.3</td>
</tr>
<tr>
<td>Textiles</td>
<td>10.9</td>
<td>14.4</td>
</tr>
<tr>
<td>Clothing</td>
<td>5.9</td>
<td>18.7</td>
</tr>
<tr>
<td>Paper</td>
<td>6.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Chemicals</td>
<td>23.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Fabricated Metals</td>
<td>5.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>6.3</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Source: Data Research Africa (1991)

Particular attention is focused here on the textile industry. Not only is this industry important in terms of size and employment, but recent research indicates that it will constitute one of a core of rapidly growing industries in the future (Hindson, King & Peart, 1996). Furthermore, as is pointed out below, the textile industry is a prime candidate for the introduction of clean technology because it is a major contributor to (water, waste and air) pollution in the region.

4. THE TEXTILE INDUSTRY IN THE GDMA

Within the GDMA, the textile industry is located primarily in the Central Zone (Congella, Mobeni & Jacobs) and the Western Zone (New Germany & Hammarsdale). This industry constitutes a major sphere of activity in the GDMA: it accounts for almost three-quarters of total textile production in the province of KwaZulu-Natal and almost half of that for South Africa as a whole. Furthermore, as already noted, this sector enjoys special significance as a source of employment. At present, the textile industry focuses primarily on the processing of natural fibres – cotton (55%) and wool (22%) – although synthetic fibres (23%) are deemed to be the future growth area (EMG, 1993: 123).

The UNEP (1996b: 6) has offered the following descriptive passage which is an accurate reflection of the situation in the textile industry in the GDMA:

The textile industry is characterised not only by the vast quantity of water required, but also by the variety of chemicals used. Generally, there is a long sequence of wet processing stages, and therefore many requirements for resource inputs and several sources of waste generation....Amongst the contributions to waste, liquid wastes tend to dominate over solid wastes and air emissions in terms of severity of environmental impact.
Of course, the nature of the wastes generated depends on the type of textile facility, the processes and technologies being operated, and the types of fibres and chemicals used.

While it is difficult to generalise about the waste streams generated in the textile industry in the GDMA, Table 3 below suggests that the major areas of concern – Specific Water Use (SWU), Specific Effluent Volume (SEV) and Specific Pollution Load (SPL) in terms of Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) – are most pronounced in the following processes: desizing, mercerising, bleaching, dyeing, printing and finishing. It is also noticeable that the wash-off printing process can be the most demanding in terms of water usage, while it is not surprising to find that colour is a problem confined to the dyeing and printing processes. It is also evident from Table 3 that SWU, SEV and SPLs are noticeable across a wide variety of fibres processed, but especially cotton and synthetic fibres.

In summary, the major issues of environmental concern may be grouped as follows:
• The wet-finishing processes utilise large quantities of water and produce a wide variety of dyes and chemicals which are discharged as liquid wastes. It has been estimated that the industry's water usage is in the region of 300-400 litres/kg; and given the need for high quality water for textile processing, very little water recycling is practised (Mohr, 1992: 3-5).

• Therefore, most of the water consumed is discharged as effluent. The major difficulty with these effluents is the presence of coloured dye residuals which, although not necessarily ‘hazardous’ in the sense of being ‘toxic’, may not be readily or completely removed in conventional sewerage treatment processes. This may impair the amenability of the treated effluent for certain re-use purposes unless it is subjected to additional advanced (and costly) treatment for colour removal (EMG, 1993: 126-127).

• By volume, solid wastes constitute the second largest waste stream in the textile industry. The principal source of solid waste is polymer, which is discharged as a by-product in the manufacture of synthetic fibres. This is mainly a chemical processing problem, which highlights the need to redefine processing boundaries in order to evaluate true impacts.

• Although air emissions data for textile manufacturing operations are not readily available, the industry acknowledges that textile mills are responsible for significant levels of air pollution, particularly in the form of sulphur dioxide (SO₄).

A brief discussion of each of these major areas of concern – together with suggestions for the adoption of clean technology – is provided below.

4.1 Water Conservation and Treatment

Textile manufacturing is one of the largest industrial producers of waste-water (Smith, 1989). On average, approximately between 300 and 400 litres of water are required to produce 1 kilogram of textile product. Textile manufacture is also a chemically intensive industry, and therefore the wastewater from textile processing contains processing bath residues from preparation, dyeing, finishing and other operations. These residues can cause damage if not properly treated before discharge to the environment (Smith, 1989a).

Waste-water from processing is the most common source of environmental concern for textile operations in the GDMA. The main unit processes that produce waste-water are washing operations. In fact, washing and rinsing operations, which are to be found in almost all areas of preparation and dyeing, are two of the most common operations in textile manufacturing that have significant potential for pollution prevention. In some cases, careful auditing and implementation of controls can achieve waste-water reductions of up to 70 per cent (Brenner, Brenner & Scholl, 1993).

By way of example, Evans (1982) reported on water consumption for a typical continuous bleach range: water consumption was more than 11,000 gallons per hour, while the washing stages accounted for 9,900 gallons per hour or 90 per cent of the total. He found that the application of the following simple, low-technology methods of water conservation reduced water use:

- Auditing and regulating flows: 300 gallons per hour savings.
- Counterflow bleaching to scouring: 3,000 gallons per hour savings.
- Counterflow scouring to desizing: 3,000 gallons per hour savings.

The total water savings without process modification was 6,300 gallons per hour, or 55 per cent of water use. Furthermore, Evans (1982) found that a simple process modification – a combined one-stage bleach and scour – could save an additional 6,200 gallons of water per hour. Elsewhere, Chandak (1994) similarly concluded that the greatest scope for waste minimisation in the textile industry lay in conserving water usage in the printing and dyeing processes, and that significant savings could be achieved through low-cost ‘good housekeeping’ methods with a pay-back period of less than one year.
Many strategies can be applied for reusing washwater. Three of the most common strategies are countercurrent washing, reducing carryover, and re-using washwater for cleaning purposes. The countercurrent washing method is relatively straightforward and inexpensive to implement in multi-stage washing processes. Basically, the least contaminated water from the final wash is reused for the next-to-last wash and so on until the water reaches the first wash stage, after which it is discharged. This technique is useful for washing after continuous dyeing, printing, desizing, scouring, or bleaching. According to Mills (1992), a typical preparation department may re-use washwater as follows:

- Re-use scour rinses for desizing.
- Re-use mercerizer washwater for scouring.
- Re-use bleach washwater for scouring.
- Re-use water-jet loom washwater for desizing.

With regard to liquid effluent treatment, the various methods used in the textile industry can be classified into one of three categories: (1) primary or mechanical; (2) biological; and (3) advanced chemical processes (UNEP, 1996b):

- Primary or mechanical treatment includes processes such as screening, neutralisation, equalisation and gravity sedimentation. The purpose of primary treatment is to remove suspended matter (including oil and grease) and to achieve uniform flows and concentrations. As the suspended matter is removed, the Biochemical Oxygen Demand (BOD) or Chemical Oxygen Demand (COD) is also reduced.
- Biological treatment is used to achieve a major reduction in the soluble effluent load (also measured in terms of BOD/COD) to meet effluent limits.
- Advanced chemical processes are used to remove suspended matter that cannot be stabilised easily, for example, substances such as chromium and phenols. Examples of such processes include chemically-assisted sedimentation, mixed media filtration, absorption and ozonation (UNEP, 1996d: 59).

Notwithstanding the comparatively poor record amongst textile mills in the GDMA, liquid effluent treatment methodologies in the textile industry are well developed. Accordingly, Smith (1994) and USEPA (1996) have recommended the following well-known strategies for eliminating offending and hard-to-treat chemicals from textile processing:

- Substituting other, easier-to-treat chemicals. For example, the substitution of linear alkylbenzene sulfonates for hard-to-treat alkylphenol (AP) in the scouring process helps to eliminate waste system pass-through and aquatic toxicity.
- Making physical process changes to avoid the need for chemicals. For example, pressure dyeing polyester eliminates the need for non-biodegradable dye carriers.
- Altering a product or raw material specification to avoid the need for chemicals. For example, finishing cotton knits mechanically at natural width and yield avoids the need for resins that contain formaldehyde, which can contribute to hazardous emissions.
- Substituting another process. For example, pad-batch dyeing of fibre reactive dyes on cotton eliminates the need for hard-to-remove salt and reduces hard-to-treat colour.

According to Chandak (1994), the investment required for the application of these modifications is relatively modest, with a pay-back period of less than five years.

### 4.2 Solid Wastes

By volume, solid wastes are the second largest waste stream in textile manufacturing, after liquid effluent waste streams. Textile processing produces many varieties of solid waste, ranging from fly ash to aluminium cans and wooden pallets. During the past two decades, significant progress has been made in curbing the generation of solid waste in textile plants (Sharma, 1993; Smith, 1994). Many industries have adopted the waste management hierarchy established by the Pollution Prevention Act of 1990 as the basis for their waste management plans. The Act emphasises prevention of pollution at the source and identifies the recycling of ‘new scrap’ at the textile mills as a financially attractive option. For wastes that cannot be reduced or recycled, the Act recommends that treatment and disposal should take place in an environmentally sound manner (Price, 1990). Unfortunately, while it is
generally recognised that the least efficient form of solid waste treatment involves dumping or landfilling, this has traditionally been the major solid waste disposal method used by most industries in South Africa, including the textile industry in the GDMA (CSIR, 1991).

Most textile operations produce little or no hazardous waste as part of their routine operations, but a small percentage of textile mills (perhaps 10 to 20 per cent) are hazardous waste generators. Any facility that uses chemicals can produce hazardous waste if a chemical exhibiting the hazardous characteristics of ignitability, toxicity, corrosivity, reactivity, or flammability is spilled on the ground. The contaminated soil from such a spill is often hazardous waste by the legal definition, although there appears to be a general reluctance on the part of textile mill managers in the GDMA to give due recognition to this potentially dangerous factor.

4.3 Air Pollution

Most processes performed in textile mills produce atmospheric emissions. Indeed, gaseous emissions have been identified as the third most serious pollution problem (after liquid effluents and solid wastes) for the textile industry (Mohr, 1993). Speculation concerning the amounts and types of air pollutants emitted from textile operations has been widespread, but, generally, air emissions data for textile manufacturing operations are not readily available (Zeller, 1985; Smith, 1989c). Nevertheless, there appears to be general agreement that the conventional source of air pollution from a textile mill is the boiler stack (UNEP, 1996c). These emissions normally consist of pollutants such as suspended particulates and sulphur dioxide (SO$_2$). Within the GDMA, by-laws specify the type and composition of fuel to be used as well as the minimum stack height for satisfactory air pollutant dispersal, although it must be said that the effective enforcement of these by-laws remains a thorny problem. Nevertheless, the available evidence indicates that most textile mills located within the GDMA are conscious of the need to introduce air emission controls, and several textile mills have installed cyclone separators, bag filters and wet scrubbers (Pollution Research Group, 1994).

The UNEP (1996c) has acknowledged that oil mists and Volatile Organic Compound (VOC) emissions to the atmosphere are more difficult to control. Nevertheless, it is suggested that reductions can be achieved by controlling the application of spinning oils and finishing agents to fabrics and by checking the heat input to evaporators. In addition, the installation of mist eliminators is also recommended. Another major source of air emissions is from organic solvent vapour released during and after drying, finishing and solvent processing operations. These vapours cannot be treated by scrubbing because they have a limited solubility in water. Although incineration has been recommended, it is an expensive process, and, in any event, emissions from incineration also need to be treated. For example, for chlorine-derived chemicals, hydrogen chloride gas is released by incineration which needs to be treated. As a result, it has been suggested that the only effective way to solve this problem is to use activated carbon for vapour absorption (UNEP, 1996c).

5 CONCLUDING COMMENTS ON THE NEED FOR INTEGRATION

Notwithstanding the environmental progress that could be achieved in the textile industry in the GDMA through the adoption of the foregoing strategies of clean technology, Holme (1992) and UNEP (1996) have identified the lack of integration in the textile industry as the major barrier to the more widespread adoption of clean technology. In the words of a USEPA (1996: 239) report:

Textiles typically are shipped from one facility to another as they progress from raw material production stages through spinning, weaving, knitting, preparation, finishing, and cut and sew. This segregated industry structure is the source of an enormous diversity of capabilities that exist to satisfy the ever-changing needs of the apparel, furnishings, and textile specialties markets. At each processing stage, however, pollutants that were added at upstream (i.e., previous) operations may be removed, while others, with the potential to cause pollution in downstream facilities, may be added.
The lack of an integrated structure within the industry means that textile operators often lack the ability to influence production methods used by upstream operators. Similarly, they have little incentive to change their own operations in order to reduce pollution produced by downstream operators. In short, the lack of integration in the industry means that opportunities to reduce pollution fail to be acted upon. Until this issue is addressed, the opportunity to adopt a truly holistic approach to clean production and clean technology in the textile industry will be severely limited.

It is evident, then, that there exists considerable scope for the implementation of clean technology in the textile industry in the GDMA. Notwithstanding the progress made in certain areas, much still remains to be done. The central issues remain those of water management, chemicals substitution, more efficient waste management and, above all, the need to address the lack of an integrated structure in the industry. Nevertheless, with the GDMA's adoption of a mutually-agreed upon framework for giving substance to the Local Agenda 21 programme, supported by the necessary research and development, the goal of localised sustainable development for the GDMA need not remain a chimera.
APPENDIX 1

GREATER DURBAN METROPOLITAN AREA

[Map of Greater Durban Metropolitan Area]
REFERENCES


Jackson, T. ‘Cleaner Production: Challenges and Opportunities’, *Policy Summary*, September.


