# LAKE VICTORIA ENVIRONMENTAL

# MANAGEMENT PROGRAM II

## SUB COMPONENT 2.2

## PROMOTION OF CLEANER PRODUCTION TECHNOLOGY

### RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP)

### GUIDANCE MANUAL FOR WET TEXTILE PROCESSING INDUSTRY

**2011**

## ACRONYMS AND ABBREVIATIONS

**BOD:** Biological Oxygen Demand

**CFC-** Hydrogenated Chlorofluorocarbon

**CO2-** Carbon Dioxide

**COD:** Chemical Oxygen Demand

**CP:** Cleaner Production

**CPCT:** Cleaner Production Centre of Tanzania

**EE:** Energy Efficiency

**EMS-** Environmental Management System

**GDP:** Gross Domestic Product

**KNCPC:** Kenya National Cleaner Production

**MVR:** Mechanical Vapor Recompression

**N:** Nitrogen

**P-** Phosphorus

**RECP:** Resource Efficient and Cleaner Production

**RR:** Renewable Resources

**RrT :** Renewable Ressources Technologies

**SS-** Suspended solids

**TN:** Total Nitrogen

**TP:** Total Phosphorous

**TVR-** Thermal vapour recompression

**UCPC :** Uganda Cleaner Production Centre

**UF-** Ultra filtration

**UNEP DTIE-**United Nations Environment Programme, Division of Technology, Industry and Economics

**UNIDO-** United Nations Industrial Development Organization

**UN-** United Nations

**USD-** United States Dollar

## PREFACE

The purpose of this Resource Efficient and Cleaner Production Sector Manual guide is to raise awareness of the environmental impacts associated with industrial and manufacturing processes. Also, it serves to highlight the approaches that industry and government can take to avoid or minimize these impacts by adopting Resource Efficient and Cleaner Production approach.
This guide is designed for two principal audiences.

- People responsible for environmental issues at sector (environmental managers or technicians) who seek information on how to improve production. In many countries, managers are ultimately responsible for any environmental harm caused by their organization's activities, irrespective of whether it is caused intentionally or unintentionally.
- Environmental consultants, Cleaner Production practitioners, employees of industry bodies, government officers or private consultants that provide advice to the industry on environmental issues.

The guide describes Cleaner Production opportunities for improving resource efficiency and preventing the release of contaminants to environment. The Cleaner Production opportunities described in this guide will help improve production as well as environmental performance.

**Chapter 1:** Gives an introduction covering mainly background information

about the sector and its contribution to the GDP and impacts to the environment.

**Chapter 2:** DescribesResource Efficiency and Cleaner Production

opportunities for each of the unit operations within the process and examples where these have

been successfully applied Quantitative data are provided for the inputs and outputs

associated with each unit operation as an indication of the typical levels of resource

consumption and waste generation.

**Chapter 3:** Provides an overview of the industry including process

descriptions, environmental impacts and key environmental indicators for the industry.

**Chapter 4:** Describes the Resource Efficient and Cleaner Production

opportunities

**Chapter 5:** Describes the RECP assessment methodology in detail. This can be used as a

reference guide for carrying out a RECP assessment within an organization.

**Chapter 6:** Provides a case study demonstrating the application Cleaner

Production in a factory.

**Chapter 7:** Describes barriers to RECP and how to overcome them

## ACKNOWLEDGEMENT

This manual (self guide) has been jointly developed by the Kenya National Cleaner Production Centre (KNCPC), Uganda Cleaner Production Centre (UCPC) and Cleaner Production Centre of Tanzania (CPCT). This is a step-by-step guide to implementing RECP in a wet textile processing plant. It is a tool to help managers and staff think about RECP in a strategic way by assessing the company's current resource use and waste generation, determining whether there is room for improvement, identifying ways to make the improvements, and then progressively implementing the changes.

The method described in this guide is based on an assessment that involves participation by several staff members in a company. It requires a significant amount of time, resources and commitment from management. Alternatively, the assessment can be undertaken by one or two individuals within an organization, or perhaps by an external consultant. It is a complete assessment, which includes raw materials, energy, water consumption, and waste generation. However, the company has the option of simply focusing on one aspect of RECP such as water or energy use.

This manual has been adapted from the "Guidance manual, Sulphur black dyeing" of Egyptian Environmental Affairs agency and Entire UK limited, January 1999 and also from the "Cleaner Production guide for textile industries" of the Lebanese Cleaner Production Centre, Beirut 2010.

# EXECUTIVE SUMMARY

This manual has been jointly developed by the Kenya National Cleaner Production Centre (KNCPC), Uganda Cleaner Production Centre (UCPC) and Cleaner Production Centre of Tanzania (CPCT). The development of this Resource Efficient and Cleaner Production (RECP) manual is meant to guide in the implementation of Resource Efficient & Cleaner Production (RECP) in the textile industries. This manual is one of the outputs of the project "*Lake Victoria Environmental Management Program, LVEMP II*", through Sub component 2.2: Promoting Cleaner Technologies in Industries.

This manual contains an analysis of the industrial production processes, including a description of the entire production cycle, main environmental problems and water, energy and material productivity issues. It provides a Resource Efficiency improvement and pollution reduction opportunities for the sector.

This guide contains the background information about the industry and its environmental issues including, quantitative data on rates of resource consumption and waste generation, where available. It presents opportunities for improving the environmental performance of industries through the application of Resource Efficient and Cleaner Production. Case studies of successful Cleaner Production opportunities are also presented.

## TABLE OF CONTENTS

# 1. INTRODUCTION

## 1.0 COUNTRY OVERVIEW OF THE TEXTILE SECTOR

### 1.1 KENYA

Agriculture is the base for economic growth, employment creation and foreign exchange earnings in Kenya. The sector accounts for about 24% of Kenya's GDP, contributes more than 50% of the country's export earnings and employs about 75% of the population.
Cotton production offers the greatest potential for increased employment, poverty reduction, rural development and generation of increased incomes in arid and semi-arid areas of the country. The sub-sector has been identified as one that could help bring rapid economic development in the country. It has therefore been classified as a core industry by the Kenyan government.

Cotton production was introduced in Kenya in the 1900's by the colonial administration. However, it was not until the early 1960's that the crop was introduced in many parts of the country, being encouraged in areas with low rainfall and therefore unsuitable for other cash crops. Currently the crop is grown in Nyanza, Western, Coast, Central, Eastern and Rift Valley provinces, largely under rain fed conditions. Cotton is also planted on irrigated land and the Government has made an effort to boost production of cotton by setting up various irrigation schemes in different arid and semi-arid parts of the country.

Kenya's cotton sector was still dominated by private colonial ginners till independence in 1963. Immediately after independence Kenya adopted an import substitution policy that ensured a backward integration of mills. Between that time and the end of 1990 the Government systematically introduced controls into the sector: it helped cooperative societies buy ginneries from the colonialists, controlled marketing margins, fixed producer prices and invested heavily in mills. The Government protected the local industry by imposing a 100% duty on imported goods, which ensured the rapid growth of the local industry with an average production capacity of over 70%. The industry also received substantial assistance from the Government and donor agencies especially in the 1980s.

In the early 80's the industry was the leading manufacturing activity in Kenya, both in terms of size and employment. The industry was employing over 200,000 farming households and about 30% of the labour force in the national manufacturing sector. However the sub-sector started declining in the mid-1980s until the 1990s. There was the dumping of used clothes locally known as "mitumba" which originally was meant for the troubled Great Lakes region but somehow ended up in the local market retailing at very low prices. This led to the collapse of the local industry in the early 1990s.

Since the liberalization of the economy in 1990, the influx of goods into Kenya also became a major problem that reduced the average capacity utilization in the mills to about 50%. The sector was actually once the fifth largest foreign exchange earner in Kenya, but dropped to a very small contribution of the Gross Domestic Product (GDP) from mid and late 90s. However, data available for the last 5 years indicates that the sector is on its way to recovery largely due to AGOA and increased Government support. The enormous market prospects presented by the African Growth and Opportunity Act (AGOA) of 2000 and the African, Caribbean and Pacific - European Union (ACP-EU) Continuous Agreement have rekindled interest in the industry. Indeed, since Kenya qualified for AGOA, its exports to the US have expanded remarkably and so has investment in this sector. Kenya's exports to the US increased from US$ 39.5 million in 1999 to US$ 277 million in 2004. Total investment in the sector rose from Kshs. 1.2 billion to Kshs. 9.7 billion, a 41% increase while jobs generated increased from about 26,000 in year 2002 to 37,000 in 2003, but dropped to 32,000 by end of 2004.

Existing and apparel firms in the country produce a large variety of products. Spinning firms produce yarn (including industrial) and sewing thread while integrated mills produce a wide variety of products including yarn, fabrics (knitted and woven), canvas, school and traveling bags, blankets, sweaters, shawls, uniforms, towels, baby nappies and knitted garments. Garment manufacturers on the other hand, produce various types of garments both for the local market and for export. About 46% of the garment manufacturers produce men's wear while the others produce woven chemise and robes, pants, Kaunda suits (for men), knitted and woven garments.

The industry has made a sizeable contribution to income generation in rural areas by providing a market for cotton. The cotton sub-sector has significant linkages with not only the processing and manufacturing industry but also with manufacturers of soaps and detergents, animal feeds, chemicals, fats and oils. These direct linkages with the processing and manufacturing firms are particularly important for the exploitation of new market opportunities presented by AGOA, European Union and other markets where Kenya can export the cotton products. Investments in growing and ginning of cotton, spinning and weaving operations, in addition to those in production of apparel and other products are assured of ready local, regional and international markets. Attractive investment incentives and production advantages are found in Kenya.

## 1.2 TANZANIA

Tanzania invested heavily in industry after its independence in 1961.The sector grew from 4 mills between 1961 and 1968 to 35 mills by 1980s as part of the government's efforts to industrialize the economy. The total investment in the sector exceeded US$ 500 million during the 1980s and consequently, the industries were the major employers and contributors to GDP. At that time the sector employed about 37,000 people (25% of the working force) and was the third contributor to the government revenue through various taxes; and the largest exporter of manufactured goods[1] and contributed 25% of GDP in manufacturing sector (SAILIN LTD (TIB1996). According to Zuku A (2002), the development of the industry was attributed to the demand and deliberate government policies.

From 1980, the economy of the country started to decline affecting all sectors including the industry which eventually collapsed. The collapse of the industry was due to inadequate supply of cotton lint, lack of power or power interruptions, high power tariffs, unfair competition from cheap imports (mainly second hand clothes) and devaluation of the Tanzania shilling which lead to difficulties in purchasing spare parts for the machines.

Beginning 2000, the government initiated commendable efforts to revive the industries partly through the privatization and investment policies. Most of the state owned industries (e.g. Sunguratex, Polytex, Canvas mills, Mwatex, Kiltex, etc) were privatized and new ones emerged (e.g. Karibu mill). By 2002, they were 50 industries in the country but only 23 (46%) were operational (MIT report, 2004). Most of these industries are involved in spinning, weaving, dyeing and printing of cotton fabrics for the local and
regional markets, although there are some which have succeeded in exporting yarn and finished garments to Europe (Ladha, 2000). It is reported that over 80 percent of Tanzanian lint cotton is exported directly to regional and international market with less than 20 percent being utilized by the local mills.

It has been reported that, in order to develop the industry in Tanzania, the government has set up a faculty of engineering at the University of Dar es Salaam which will begin enrolling students in September 2011. Typical wet processes are water intensive. Hence critical environmental problems in industries are mainly those associated with water pollution caused by the discharge of untreated effluents.

Most of the industries in Tanzania lack efficient effluent treatment systems to reduce the impacts on environmental pollution.

1

## 1.3 UGANDA

Cotton has traditionally been one of Uganda's most important export commodities. Uganda offers an excellent climate and soils for the cultivation of cotton and produces a high-grade fiber of medium-staple. It is a 'bright white' cotton for which there is a sustained international market. The cotton sector prospered in the 1960s and early 1970s, producing around 86.3 thousand metric tons at its peak and contributing around 40% of foreign exchange earnings. However, during the period from 1974/75 to 1993/94 external and internal political and economic turmoil dramatically reduced cotton's contribution to economic growth, foreign exchange earnings, and rural incomes.

Currently, however, it accounts for only about 5.5% of the country's foreign exchange earnings. Total exports in 1999/00 were 14,500 metric tons (around 100,000 bales), or $22 million in total export value. It is estimated to contribute to the incomes of 10% of the country's population (or 2.5 million people in the rural areas of the east, north, and west). Second to coffee cotton is the most important crop in helping to alleviate poverty in rural areas. It is expected that a revival of cotton exports could positively affect the incomes of around 15% of the rural population and significantly contribute to the alleviation of poverty.

Additional value-added operations, ranging from production, edible oils, soaps, and livestock feed would spread income support to another 2 to 3 percent of the country's population in urban areas. Thus, 18% of the country's population will benefit from a revived cotton industry. Also, if garment exports can be substantially expanded under AGOA this income impact could be even greater.

## 2. RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP)

### 2.1 What is Resource Efficient and Cleaner Production (RECP)

Over the years, industrialized nations have progressively taken different approaches to dealing with environmental degradation and pollution problems, by:

- Ignoring the problem;
- Diluting or dispersing the pollution so that its effects are less harmful or apparent;
- Controlling pollution using 'end-of-pipe' treatment;
- Preventing pollution and waste at the source through a 'resource efficient and cleaner production' approach

The gradual progression from 'ignore' through to 'prevent' has culminated in the realization that it is possible to achieve economic savings for industry as well as an improved environment for society. This, essentially, is the goal of Resource Efficient and Cleaner Production.

### 2.2 Definition of RECP

Resource Efficient and Cleaner Production (RECP) is defined by UNIDO and UNEP as the continuous application of an integrated preventive environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment.

It specifically works to advance the three dimensions of sustainable development in an integrated manner, by catalyzing:

- Production Efficiency through optimization of the productive use of natural resources (materials, energy and water) by enterprises and other organizations;
- Environmental Management through minimization of the impact on environment and nature, by preventing the generation of waste and emissions and improving the use of chemicals in enterprises and other organizations; and
- Human Development through minimization of risks to people and communities from enterprises and other entities and supporting their own development.

### 2.3 RECP Techniques

*Good Housekeeping*

Good work practices and techniques such as proper maintenance can produce significant benefits at no or low cost

*Process optimization*

Resource consumption can be reduced by optimizing existing processes.

*Raw material substitution*

Environmental problems can be avoided by replacing hazardous materials with more environmentally benign materials.

*New Technology*

Adopting new technologies can reduce resource consumption and minimize waste generation through improved operating efficiencies. Technological improvements can occur in a number of ways:

- Changing manufacturing processes and technology;
- Changing the nature of process inputs (ingredients, energy sources, recycled water etc.)
- Changing the final product or developing alternative products;
- On-site reuse of wastes and by-products

*New product Design*

Changing product design can result in benefits throughout the life cycle of the product, including reduced use of hazardous substances reduced waste disposal, reduced energy consumption and more efficient production processes. New product design is a long-term strategy and may require new production equipment and marketing efforts but payback can ultimately be very rewarding

*Changing attitudes*

It is important to stress that RECP is about attitudinal as well as technological change. In many cases, the most significant RECP benefits can be gained through lateral thinking, without adopting technological solutions. A change in attitude on the part of company directors, managers and employees is crucial to gaining the most from RECP.

### 2.4 Difference between RECP and Pollution Control

The key difference between pollution control and RECP is one of timing. Pollution control is an after-the-event, 'react and treat' approach, whereas RECP reflects a proactive, 'anticipate and prevent' philosophy. Prevention is always better than cure. This does not mean, however, that 'end-of-pipe' technologies will never be required. By using a RECP philosophy to tackle pollution and waste problems, the dependence on 'end-of-pipe' solutions may be reduced or in some cases, eliminated altogether. RECP can be and has already been applied to raw material extraction, manufacturing, agriculture, fisheries, transportation, tourism, hospitals, energy generation and information systems.

### 2.5 Why invest in Resource Efficient and Cleaner Production?

Investing in RECP, to prevent pollution and reduce resource consumption is more cost effective than continuing to rely on increasingly expensive 'end-of-pipe'. The initial investment for RECP options and for installing pollution control technologies may be similar, but the ongoing costs of pollution control will generally be greater than for RECP. Furthermore, the RECP options generate savings through reduced costs for raw materials, energy, waste treatment and regulatory compliance.

*Greener products*

The environmental benefits of RECP can be translated into market opportunities for 'greener' products. Companies that factor environmental considerations into the design stage of a product will be well placed to benefit from the marketing advantages of any future eco-labeling schemes.

Some reasons to invest in Cleaner Production

- Improvements to product and processes;
- Savings on raw materials and energy, thus reducing production costs;
- Increased competitiveness through the use of new and improved technologies;
- Reduced concerns over environmental legislation;
- Reduced liability associated with the treatment, storage and disposal of hazardous wastes;
- Improved health, safety and morale of employees;
- Improved company image;
- Reduced costs of end-of-pipe solutions

### 2.6 Cleaner Production and Sustainable Development

In the past, companies have often introduced processes without considering their environmental impact. They have argued that a trade-off is required between economic growth and the environment, and that some level of pollution must be accepted if reasonable rates of economic growth are to be achieved. This argument is no longer valid, and the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992, established new goals for the world community that advocate environmentally sustainable development.

*Economy and environment go hand in hand*

RECP can contribute to sustainable development, as endorsed by Agenda 21. RECP can reduce or eliminate the need to trade off environmental protection against economic growth, occupational safety against productivity and consumer safety against competition in international markets.

Setting goals across a range of sustainability issues leads to 'win–win' situations that benefit everyone. RECP is such a 'win–win strategy: it protects the environment, the consumer and the worker while also improving industrial efficiency, profitability and competitiveness.

*RECP can provide advantages for all countries*

RECP can be especially beneficial to developing countries and those undergoing economic transition. It provides industries in these countries with an opportunity to 'leapfrog' those more established industries elsewhere that are saddled with costly pollution control.

## 2.7 Cleaner Production and Quality and Safety

Food safety and food quality are very important aspects of the food industry. While food safety has always been an important concern for the industry, it has received even greater attention over the past decade due to larger scales of production, more automated production processes and more stringent consumer expectations. A stronger emphasis is also being placed on quality due to the need for companies to be more efficient in an increasingly competitive industry. In relation to food safety, Hazard Analysis Critical Control Point (HACCP) has become a widely use tool for managing food safety throughout the world. It is an approach based on preventing microbiological, chemical and physical hazards in food production processes by anticipating and preventing problems, rather than relying on inspection of the finished product. Similarly, quality systems such as Total Quality Management (TQM) are based on a systematic and holistic approach to production processes and aim to improve product quality while lowering costs. RECP should operate in partnership with quality and safety systems and should never be allowed to compromise them. As well, quality, safety and RECP systems can work synergistically to identify areas for improvement in all three areas.

## 2.8 RECP and Environmental Management Systems

Environmental issues are complex, numerous and continually evolving, and an *ad hoc* approach to solving environmental problems is no longer appropriate. Companies are therefore adopting a more systematic approach to environmental management, sometimes through a formalized environmental management system (EMS). RECP helps companies to implement EMS effectively and provides a company with a decision-making structure and strategy in managing the day-to-day operations.

## 3. OVERVIEW OF WET TEXTILE PROCESSING

Wet textile processing involves a wide range of raw materials, machineries and processes to engineer the required shape and properties of the final product. The processes are essentially based on water, chemicals /dyes and energy in the form of steam and electricity that are required in the various activities along the chain to have a final finished product.

### 3.1 Process Overview

Typical wet textile processing follows the following chain:

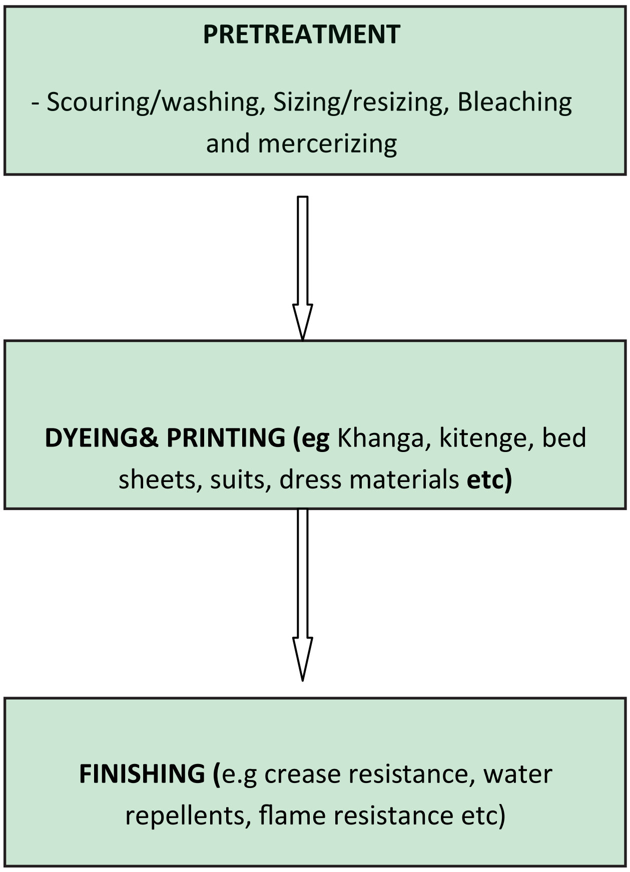


**Figure 1 showing typical wet textile processing.**

#### 3.1.1 Washing/scouring

This process removes natural and acquired impurities from cotton, linen and wool fibres and fabrics. Agents used in the scouring process are detergents, soaps, alkalis, anti-static compounds, wetting agents, foamers, defoamers, complexing agents and lubricants. Synthetic fabrics are only lightly scoured to remove sizes. Scouring is sometimes carried out by dry cleaning, using solvents. The main solvents in dry cleaning are CFCs and HCFCs. Trichloroethylene is carcinogenic and 1, 1, 1-trichloroethane, CFCs and HCFCs deplete the ozone layer.

### 3.1.2 Sizing/desizing

Before weaving, the yarn is strengthened by sizes. Sizes can either be starch-based or synthetic. Common synthetic sizes are acrylates, polyvinyl alcohol (PVA) and carboxymethylcellulose (CMC). After the weaving the starch is removed from them, this is also known as desizing. This can be done by means of enzymes, by oxidation substances or by water-soluble sizing substances. An oxidation system instead of an enzyme system has generally lower impact on the environment. In principle, the use of water-soluble sizing (like PVA and CMC) is the least environmentally hazardous. The process involves wetting the fabric with enzymes and steaming it at higher temperatures i.e. 100degree centigrade followed by washing with plenty of water.

### 3.1.3. Bleaching

Fabrics are often whitened by bleaching prior to dyeing or printing. Hydrogen peroxide, sodium chlorite and sodium hypochlorite are the most common bleaching agents. Other bleaching agents used are per acetic acid and sodium perborate. Auxiliary chemicals such as surfactants, optical brighteners, antifoam and wetting agents are also used. Fabrics made from synthetic fibres often do not need to be bleached, and regenerated cellulose fabrics are more lightly bleached than cotton. Blends of synthetic and cotton fibres are commonly bleached. Wool is often bleached by using hydrogen peroxide or bisulphate. Bleaching process can be done continuously or batch wise. Continuous bleaching generally costs about 5 to 15 times less water than batch bleaching.

### 3.1.4 Mercerizing

After the bleaching, the bleaching chemical has to be removed before the dye is applied; otherwise, the bleach and dye react to each other. The traditional method of removing the bleach is by rinsing the fabric in water a number of times, which uses a lot of water. Mercerizing is mostly done by treating the fabric with strong concentrated caustic soda (NaOH) at room temperatures. NaOH could be recovered from mercerizing using membrane technology or by effective evaporation. Recovery systems can reclaim up to 98% of the caustic. Continuous mercerizing generally uses much less water than a batch process (about 8 to 30 times less).

### 3.1.5. Dyeing/printing

The dyeing and printing processes are very polluting and use a vast quantity of water. Lots of different chemicals are used and the improvement options are various. Continuous dying process is efficient than batch wise dyeing process and screen printing is faster and efficient than roller printing. Washing process which follows after dying process uses extremely large amount of water. If not recovered/recycled these waste water are left to drain into the streams

### 3.1.6 Finishing

Finishing is the treatment of fabrics in order to achieve special characteristics, for example water, flame or wrinkle resistance. Halogenated compounds such as bromated diphenylethers (PBDEs) and compounds are used as flame-retardants and are very problematic from an environmental point of view. Inorganic salts and phosphonates are better alternatives, although not entirely satisfactory from the quality point of view. Biocides such as chlorinated phenols (PCP), metallic salts (arsenic, zinc, copper or mercury), DDE and DDT are used as preservatives on exported fabrics to prevent mildew and mold. All these substances are highly toxic.

## 3.2 Environmental Impacts

Waste streams generated in the wet textile processing industry are essentially based on water-based effluent generated in the various activities along the process stream. The main cause of generation of this effluent is the use of huge volume of water in the actual chemical processing during re-processing in preparatory, dyeing, printing and finishing stages. In fact, in a practical estimate, it has been found that 45% material in preparatory processing, 33% in dyeing and 22% are re-processed in finishing.

Waste generated in textile industry can be categorized as hard to treat waste, hazardous or toxic and high volume waste. Hard to treat waste are effluent containing no-biodegradable organic or inorganic materials such as color and metal salts used during dyeing and printing processes. Hazardous /toxic waste are those effluents that contain chlorinated solvents and caustic soda used in mercerizing process and printing as well as used in cleaning of machineries and finishing processes . High volume wastes are those wastes that contain high volume of water. Processes such as mercerizing, printing and dyeing use large volume of water, consequently if not recycled end in effluent streams.

Dyeing/printing processes are very polluting and use a vast quantity of water, chemicals and dyes which are very hard to treat waste and therefore contaminate the environment if not well treated. Printing of Khanga and Kitenge which covers more than 50% of the production output in Tanzania mills generate vast amount of unwanted and hard to treat pollutant effluents. These effluents are in many cases are left down the streams untreated.

Below is a typical wet textile process flow showing the inputs and outputs which may cause impact to the environment.

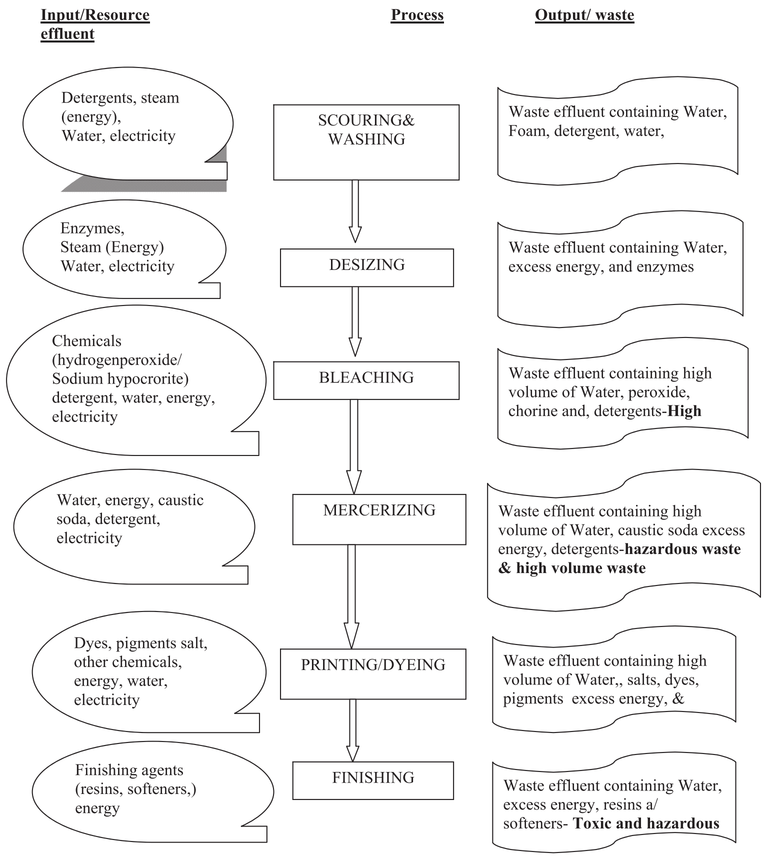


**Figure 2: Typical Process Flow Chart of a Wet Textile Industry**

## 3.3 OCCUPATIONAL HEALTH AND SAFETY

Workers in the industry are prone to occupational health and safety impacts which may cause permanent or temporary damage to their health. Health and safety impacts are caused by workers being exposed to different process involved in the operations including, among others, chemicals agents and dyestuffs; dust and fibers; noise; and accidents. Personal protective gears such as masks, boots, gloves, etc. are recommended to be provided and used by the workers at all times during work.

## 4. RESOURCE EFFICIENT AND CLEANER PRODUCTION OPPORTUNITIES

### 4.1 Water Use

Wet processing requires water at almost every at every stage of the production process. Excessive water use can deplete water sources for future production or community use and increases the associated energy costs for pumping. Reduction in water usage can provide substantial savings.

**Some of the key questions to consider while carrying out water audit:**

- Is water left running when it is not in use?
- Is fresh water used in every stage of production? Could some water be reused?
- How much money does the business pay for water, and how much could it reduce that cost through more efficient use?

**Selected mitigation strategies:**

- Reuse water from "cleaner" stages of production in "dirtier" stages of the next production cycle. For example, use rinse water from the final stage of one production cycle in the first-stage rinsing of the next batch.
- Decrease water usage through "dry cleanup." Dry cleanup involves initial cleaning without water (by sweeping or wiping down) before washing. This method reduces the amount of water required to dislodge solid or semi-solid wastes from floors or machinery.
- Regulate water flow. Using high-pressure water hoses can ease cleaning and cut water use; often this can be accomplished simply byadding a new nozzle to the end of a hose.
- Limit water loss between production stages. Turn off water when transferring materials from one bath to another, since leaving the water running causes substantial water loss. Prevent baths from overflowing by monitoring water levels closely or installing an automatic shut-off mechanism.

### 4.2 Chemicals

Chemical dyes and solvents may represent a significant part of production costs if due to inefficient production methods. Excessive chemical use also increases risks of contamination and may affect the health of workers. Efficient chemical use lowers production costs and lessens environmental impacts.

**Some of the key questions to consider:**

- Where are chemicals stored and in what quantities?
- Are material specification sheets provided for the chemicals in use?

- Are workers trained in correct measurement and application techniques?
- Are different kinds of chemicals available for the same application?

**Selected mitigation strategies:**

- Improve chemical application techniques. Spot-apply solvents instead of pouring; this helps avoid spills and stops excessive chemical use.
- Use correct measurements to reduce waste or spoilage.
- Consider using less dangerous or damaging chemicals. Replace potentially carcinogenic (cancer-causing) chemical inks with vegetable-based inks and use lower-foaming detergents or solvents with less isopropyl alcohol to reduce pollution.
- Reuse certain chemicals and investigate which chemicals can be reused or recycled. Caustic soda, for example, can be recaptured from the mercerizing process (anintermediate step in refinishing) through evaporation.
- Improve chemical storage and include signs to clearly indentify different chemicals.
- Ensure that chemicals and dyes are stored in tightly sealed containers that do not leak.

## 4.3 Improper use and poor maintenance of machinery and equipment.

Improper use of machinery or equipment can increase waste generation and leads to raising costs for inputs and, often, for waste disposal.

**Some key issues to consider:**

- How well are workers trained in machine operation?
- Is equipment well maintained?
- Is there a regular maintenance schedule and checklist?
- Are machines used to their full capacity?

**Selected mitigation strategies:**

- Train workers in proper maintenance and operation of machines.
- Use machines at full capacity for this increases output and saves energy
- Use appropriately sized equipment to match different tasks
- Minimize leakage and blockage in equipment.
- Monitor machinery to prevent fuel or water leakage; clean debris from sumps and screens to improve efficiency.

## 4.4 Intermittent Production

Advance planning can lessen waste that occurs in between production stages and reduce some of the inefficiencies.

**Some key questions to consider:**

- How unpredictable are production requests?
- Do they follow a pattern?
- How are inputs or machinery stored in between production cycles?

**Selected mitigation strategies:**

- Increase production efficiency through improved record-keeping. Documenting production requests helps to determine production trends over time, for example, during certain seasons it is easier to forecast anticipated demand.
- Check equipment for leaks and repair immediately so that production will not be delayed when it restarts.
- Plan input purchases to minimize leftovers (of chemicals, materials, etc.) once production has ended.
- Use minimum amounts of chemical or fuel inputs to increase efficiency and reduce losses in between production stages.

## 4.5 Working conditions

Production may result in hazardous working conditions if aspects like excessive heat caused by operating machinery, lack of ventilation and skin-irritating chemicals are overlooked.

**Some key questions to consider:**

- What kinds of fumes are produced in the different stages of production?
- Are there any by-products from production that cause skin, eye or breathing irritation, even occasionally?
- Are any of the chemicals used known to be potentially cancer-causing?
- Are gloves, boots, face masks or other protective clothing available for workers?

**Selected mitigation strategies:**

- Develop and implement a health and safety plan. Sometimes small changes such as buying face masks or rubber gloves can dramatically reduce potential harm to workers.

- Train workers in accident prevention. Designate one person as the safety trainer and have that person train others.

- Check existing safety equipment regularly; replace elements like filters frequently.

- Provide tight-fitting covers for chemical baths, to reduce sickening fumes and minimize evaporation of costly chemicals.

- Increase ventilation inside buildings and around chemical baths to avoid fumes that could harm the workers. The use of fans, covers and/ or chimneys can help minimize fume inhalation outdoors or indoors.

- Consider organizing production to allow rotation of workers, so that individual workers do not spend too much time at one place of work.

### 4.6 Energy Efficiency

Most energy used in production occurs in heating dye baths and in rinsing and drying fabrics. Inefficient use or overuse of energy during these production stages contributes to pollution and higher operating costs. Reducing energy use can save costly or scarce resources but also reduce associated air pollution some of which are greenhouse gases.

**Some key questions to consider:**

- What type of fuel is used in production and in what quantities?
- Which production stages use the most fuel?

**Selected mitigation strategies:**

- Use alternative fuel types. Organic wastes, such as rice husks and bagasse, can supplement scarce fuel sources such as wood. Renewable energy sources, such as solar hot water heating or photovoltaic (solar) cells, may be a cost-effective option in some cases, but cost, availability and applicability of the technology should be carefully assessed.

- Improve heat transfer and insulation of pipes and bath containers to reduce energy loss and decrease fuel needs.
- Regulate fuel use to meet needs to meet production requirements.

- Implement energy conservation methods.
- Use a thermometer to maintain the most efficient bath temperature.
- Make more efficient use of production time, and prevent excessive use of fuel (due to overheating or reheating baths). Consider planning the facility's production cycles to reuse bathwater that is still hot from a previous use.
- Match equipment rating to output
- Use efficient lighting equipment, motion or occupancy sensors and timers

## 4.7 Wastewater

Wastewater from production is often contaminated with chemical dyes, solvents or salts. Contaminated water endangers the health of workers and the surrounding community. In the long run, contaminated wastewater can make the local water supply undrinkable and ruin local farmers' crops. These problems may force operations to pay for procuring clean water from other locations or to clean the water on-site before using it.

**Key questions to consider:**

- Where is wastewater discharged?
- What treatment methods are currently used in production?
- What kinds of chemicals are used and what dangers do they pose?

**Selected mitigation strategies:**

- Separate chemically contaminated water from organic wastewater. Water with un-dyed fibers or dirt in it does not present a health hazard and can even be used as fertilizer. However, water that i contaminated by chemicals or other substances will need some type of treatment to make it safe for release into the environment. Consult with an expert to determine what treatment methods are appropriate for the individual facility's wastewater.
- Ensure that dyes or chemical-coated materials are cleaned away from water sources and with as little water as possible.
- Avoid spills that can contaminate water supplies.

## 5. RESOURCE EFFICIENT AND CLEANER PRODUCTION ASSESSMENT

A cleaner Production Assessment is a methodology for identifying areas of inefficient use of resources and poor management of wastes, by focusing on the environmental aspects and thus the impacts of industrial processes. Many organizations have produced manuals describing Cleaner Production assessment methodologies at varying levels of detail. However, the underlying strategies are much the same. The basic concept centers on a review of a company and its production processes in order to identify areas where resource consumption, hazardous materials and waste generation can be reduced. Table 2 lists some of the steps described in the more well-known methodologies.

**Table 1 Methodologies for undertaking a Cleaner Production assessment**

| Organization | Document | Methodology |
|---|---|---|
| **UNEP, 1996** | *Guidance materials for UNIDO/UNEP National Cleaner Production Centers* | 1. Planning and Organization<br>2. Pre-assessment<br>3. Assessment<br>4. Evaluation and feasibility study<br>5. Implementation and continuation |
| UNEP, 1991 | Audit and reduction manual for industrial emissions and waste<br>Technical report series NO. 7 | 1. Pre-assessment<br>2. Material balance<br>3. Synthesis |
| **Dutch Ministry of Economic Affairs, 1991** | *Prepare Manual for the Prevention of Waste and Emissions* | 1. Planning and Organization<br>2. Assessment<br>3. Feasibility<br>4. Implementation |
| **USEPA, 1992** | *Facility Pollution Prevention Guide* | 1. Development of pollution prevention<br>2. Programme<br>3. Preliminary assessment |

The rest of this chapter describes the steps within a Resource Efficiency and Cleaner Production assessment as outlined in the UNEP/UNIDO document, *Guidance Materials for UNIDO/UNEP National Cleaner Production Centers*. (UNEP, 1995)

**The steps from this methodology are detailed further in Figure 3**

Phase I: Planning and organization

- Obtain management commitment
- Establish a project team
- Develop policy, objectives and targets
- Plan the Cleaner Production assessment

Phase II: Pre-assessment (qualitative review)

- Company description and flow chart
- Walk-through inspection
- Establish a focus

Phase III: Assessment (quantitative review)

- Collection of quantitative data
- Material balance
- Identify Cleaner Production opportunities
- Record and sort options

Phase IV: Evaluation and feasibility study

- Preliminary evaluation
- Technical evaluation
- Economic evaluation
- Environmental evaluation
- Select viable options

Phase V: Implementation and continuation

- Prepare an implementation plan
- Implement selected options
- Monitor performance
- Sustain Cleaner Production activities

**Figure 4 Overview of the Cleaner Production assessment methodology (UNEP, 1996)**

## 5.1 Planning and Organization

The objective of this phase is to obtain commitment to the project, initiate systems, allocate resources and plan the details of the work to come. A project has more chance of success if this groundwork is done well.

### 5.1.1 Obtain management commitment

Experience from companies throughout the world shows that Cleaner Production results in both environmental improvements and better economic performance. However, this message has to reach the management of the company. Without management commitment the Cleaner Production assessment may be only a short-term environmental management tool.

### 5.1.2 Establish a project team

It is best to establish a project team as early in the process as possible. The project team is responsible for progression of the assessment and will normally undertake the following tasks:

- Analysis and review of present practices (knowledge);
- Development and evaluation of proposed Cleaner Production initiatives (creativity).
- Implementation and maintenance of agreed changes (authority).

### 5.1.3 Develop environmental policy, objectives and targets

The environmental policy outlines the guiding principles for the assessment. It acts to focus efforts in a way considered most important by management. The environmental policy can be refined as the project team gains more insight into the Cleaner Production possibilities within the company.

The policy contains the company's mission and vision for continuous environmental improvement and compliance with legislation. Objectives describe how the company will do this. For example, objectives could include reducing consumption of materials and minimizing the generation of waste. Targets are measurable and scheduled, and are used to monitor if the company is proceeding as planned. An example of a target might be a 20% reduction in electricity consumption within 2 years. In general, objectives and targets should be

- Acceptable to those who work to achieve them.
- Flexible and adaptable to changing requirements.
- Measurable over time (targets only).
- Motivational.
- In line with the overall policy statement.

### 5.1.4 Plan the Cleaner Production assessment

The project team should draw up a detailed work plan and a time schedule for activities within the Cleaner Production assessment. Responsibilities should be allocated for each task so that staffs involved in the project understand clearly what they have to do. It is also wise to anticipate any problems or delays that may arise and plan for them accordingly. Lengthy delays and problems arising out of poor planning erode motivation at both the worker and management level.

## 5.2 Pre-assessment

The objective of the pre-assessment is to obtain an overview of the company's production and environmental aspects. Production processes are best represented by a flow chart showing inputs, outputs and environmental problem areas.

### 5.2.1 Company description and flow chart

A description of the company's processes should answer the following questions:

- What does the company produce?
- What is the history of the company?
- How is the company organized?
- What are the main processes?
- What are the most important inputs and outputs?

Processes which take place as part of the company's activities can be represented using a detailed process flow chart. Flow chart production is a key step in the assessment and forms the basis for material and energy balances which occur later in the assessment. Process flow charts should pay particular attention to activities which are often neglected in traditional process flow charts, such as:

- Cleaning;
- Materials storage and handling;
- Ancillary operations (cooling, steam and compressed air production);
- Equipment maintenance and repair;
- Materials that are not easily recognizable in output streams (catalysts, lubricants etc.);
- By-products released to the environment as fugitive emissions.

The process flow chart is meant of providing an overview and should thus be accompanied by individual input/output sheets for each unit operation or department.

### 5.2.3 Walk-through inspection

Much of the information needed to fill out the input/output sheets, described above, may be obtained during a walk-through inspection of the company.

The walk-through inspection should, if possible, follow the process from the start to the finish, focusing on areas where products, wastes and emissions are generated. During the walk-through, it is important to talk to the operators, since they often have ideas or information that can be useful in identifying sources of waste and Cleaner Production opportunities. The text box over page provides examples of the types of questions that may be asked to prompt the investigation.

During the walk-through problems encountered along the way should be listed, and if there are obvious solutions to these they should also be noted. Special attention should be paid to no-cost and low-cost solutions. These should be implemented immediately, without waiting for a detailed feasibility analysis.

### 5.2.4 Establish a focus

The last step of the pre-assessment phase is to establish a focus for further work. In an ideal world, all processes and unit operations should be assessed. However time and resource constraints may make it necessary to select the most important aspect or process area. It is common for Cleaner Production assessments to focus on those processes that:

- Generate a large quantity of waste and emissions;
- Use or produce hazardous chemicals and materials;
- Entail a high financial loss;
- Have numerous obvious Cleaner Production benefits;
- Are considered to be a problem by everyone involved.

All the information collected during the pre-assessment phase should be well organized so that it is easily accessed and updated.

Some of the Questions to be answered during a walk-through inspection include:

- Are there signs of poor housekeeping (untidy or obstructed work areas etc.)?
- Are there noticeable spills or leaks? Is there any evidence of past spills, such as discoloration or corrosion on walls, work surfaces, ceilings and walls, or pipes?
- Are water taps dripping or left running?
- Are there any signs of smoke, dirt or fumes to indicate material losses?
- Are there any strange odours or emissions that cause irritation to eyes, nose or throat?
- Is the noise level high?
- Are there open containers, stacked drums, or other indicators of poor storage procedures?
- Are all containers labeled with their contents and hazards?
- Have you noticed any waste and emissions being generated from process equipment (dripping water, steam, evaporation)?
- Do employees have any comments about the sources of waste and emissions in the company?
- Is emergency equipment (fire extinguishers etc.) available and visible to ensure rapid response to a fire, spill or other incident?

## 5.3 Assessment

The aim of the assessment phase is to collect data and evaluate the environmental performance and production efficiency of the company. Data collected about management activities can be used to monitor and control overall process efficiency, set targets and calculate monthly or yearly indicators. Data collation activities can be used to evaluate the performance of a specific process.

### 5.3.1 Collection of quantitative data

It is important to collect data on the quantities of resources consumed and wastes and emissions generated. Data should be represented based on the scale of production: for example: water consumption per tonne of made product. Collection and evaluation of data will most likely reveal losses. For instance, high electricity consumption outside production time may indicate leaking compressors or malfunctioning cooling systems.

In determining what data to collect, use the input/output worksheets, described previously, as a guide. Most data will already be available within the company recording systems, e.g. stock records, accounts, purchase receipts, waste disposal receipts and the production data. Where information is not available, estimates or direct measurements will be required.

### 5.3.2 Material balance

The purpose of undertaking a material balance is to account for the consumption of raw materials and services that are consumed by the process, and the losses, wastes and emissions resulting from the process. A material balance is based on the principle of 'what comes into a plant or process must equal what comes out'. Ideally inputs should equal outputs, but in practice this is rarely the case, and some judgment is required to determine what level of accuracy is acceptable.

A material balance makes it possible to identify and quantify previously unknown losses, wastes or emissions, and provide an indication of their sources and causes. Material balances are easier, more meaningful and more accurate when they are undertaken for individual unit operation. An overall company-wide material balance can then be constructed with these.

The material balance can also be used to identify the costs associated with inputs, outputs and identified losses. It is often found that presenting these costs to management can result in a speedy implementation of Cleaner Production options.

While it is not possible to lay down a precise and complete methodology for undertaking a material balance, the following guidelines may be useful

- Prepare a process flow chart for the entire process, showing as many inputs and outputs as possible.

- Sub-divide the total process into unit operations. (Sub-division of unit operations should occur in such a way that there is the smallest possible number of streams entering and leaving the process).
- Do not spend a lot of time and rescues trying to achieve a perfect material balance; even a preliminary material balance can reveal plenty of Cleaner Production opportunities

Environmental performance indicators for the process can be developed from the material balance data. This is achieved by dividing the quantity of a material input or waste stream by the production over the same period. Performance indicators may be used to identify over-consumption of resources or excessive waste generation by comparing them with those of other companies or figures quoted in the literature. They also help the company track its performance towards its environmental targets.

### 5.3.3 Identify Cleaner Production opportunities

Identifying Cleaner Production opportunities depends on the knowledge and creativity of the project team members and company staff, much of which comes from their experience. Many Cleaner Production solutions are arrived at by carefully analyzing the cause of a problem.

Another way of identifying Cleaner Production opportunities is to hold a 'brainstorming' session, where people from different parts of the organization meet to discuss solutions to specific problems in an open and non-threatening environment.

Some other sources of help from outside the organization could be:

- this guide;
- external industry personnel or consultants;
- trade associations;
- universities, innovation centers, research institutions, government agencies;
- equipment suppliers;
- information centers, such as UNEP or UNIDO;
- literature and electronic databases

### 5.3.4 Record and sort options

Once a number of Cleaner Production opportunities have been suggested and recorded, they should be sorted into those that can be implemented directly and those that require further investigation.

It is helpful to follow the following steps:

- Organize the options according to unit operations or process areas, or according to inputs/outputs categories (e.g. problems that cause high water consumption).

- Identify any mutually interfering options, since implementation of one option may affect the other
- Opportunities that are cost free or low cost, that do not require an extensive feasibility study, or those are relatively easy to implement, should be implemented immediately.
- Opportunities that are obviously unfeasible, or cannot be implemented should be eliminated from the list of options for further study.

*Table 2 Example of information recorded for identified options*

| Problem type | Problem description | Cleaner Production Options |
|---|---|---|
| Examples:<br>• Resource Consumption<br>• energy consumption<br>• air pollution<br>• solid waste<br>• Wastewater<br>• Hazardous waste<br>• occupational health and safety | Examples:<br>• name of process and Department<br>• short background of Problem<br>• amount of materials lost or concentration of pollutants<br>• money lost due to lost resources | Examples:<br>• how the problem can be solved<br>• short-term solution<br>• Long-term solution<br>• estimated reductions in resource consumption and Waste generation |

## 5.4 Evaluation and feasibility study

The objective of the evaluation and feasibility study phase is to evaluate the proposed Cleaner Production opportunities and to select those suitable for implementation.

The opportunities selected during the assessment phase should all be evaluated according to their technical, economic and environmental merit. However, the depth of the study depends on the type of project. Complex projects naturally require more thought than simple projects. For some options, it may be necessary to collect considerably more information. An important source of this information may be employees affected by the implementation.

### 5.4.1 Preliminary evaluation

The quickest and easiest method of evaluating the different options is to form a group, consisting of the project team and management personnel, and discuss the possible solutions one by one. This process should give a good indication of which projects are feasible and what further information is required.

### 5.4.2 Technical evaluation

The potential impacts on products, production processes and safety from the proposed changes need to be evaluated before complex and costly projects can be decided upon. In addition, laboratory testing or trial runs may be required when options significantly change existing practices. A technical evaluation will determine whether the opportunity requires staff changes or additional training or maintenance.

### 5.4.3 Economic evaluation

The objective of this step is to evaluate the cost effectiveness of the Cleaner Production opportunities. Economic viability is often the key parameter that determines whether or not an opportunity will be implemented.

When performing the economic evaluation, costs of the change are weighed against the savings that may result. Costs can be broken into capital investments and operating costs. Standard measures used to evaluate the economic feasibility of a project are payback period, net present value (NPV), or internal rate of return (IRR).

Capital investment is the sum of the fixed capital costs of design, equipment purchase, installation and commissioning, costs of working capital, licenses, training, and financing. Operating costs, if different to existing conditions will need to be calculated. It may be that operating costs reduce as a result of the change, in which case, these should be accounted for in the evaluation as an ongoing saving.

### 5.4.4 Environmental evaluation

The objective of the environmental evaluation is to determine the positive and negative environmental impacts of the option. In many cases the environmental advantages are obvious: a net reduction in toxicity and/or quantity of wastes or emissions. In other cases it may be necessary to evaluate whether, for example, an increase in electricity consumption would outweigh the environmental advantages of reducing the consumption of materials.

For a good environmental evaluation, the following information is needed: changes in amount and toxicity of wastes or emissions;

- Changes in energy consumption;
- Changes in material consumption;
- Changes in degradability of the wastes or emissions;
- Changes in the extent to which renewable raw materials are used;

- Changes in the reusability of waste streams and emissions;
- Changes in the environmental impacts of the product.

In many cases it will be impossible to collect all the data necessary for a good environmental evaluation. In such cases a qualified assessment will have to be made, on the basis of the existing information.

Given the wide range of environmental issues, it will probably be necessary to prioritize those issues of greatest concern. In line with the national environmental policy of the country, some issues may have a higher priority than others.

**Aspects to be considered in the evaluation are:**

**i) Preliminary evaluation**

Is the Cleaner Production option available?

- Can a supplier be found to provide the necessary equipment or input material?
- Are consultants available to help develop an alternative?
- Has this Cleaner Production opportunity been applied elsewhere? If so, what have been the results and experience?
- Does the option fit in with the way the company is run?

**ii) Technical evaluation**

- Will the option compromise the company's product?
- What are the consequences for internal logistics, processing time and production planning?
- Will adjustments need to be made in other parts of the company?
- Does the change require additional training of staff and employees?

**iii) Economic evaluation**

- What are the expected costs and benefits?
- Can an estimate of required capital investment be made?
- Can an estimate of the financial savings be made, such as reductions in environmental costs, waste treatment costs, material costs or improvements to the quality of the product?

**iv) Environmental evaluation**

- What is the expected environmental effect of the option?
- How significant is the estimated reduction in wastes or emissions?
- Will the option affect public or operator health (positive or negative)? If so, what is the magnitude of these effects in terms of toxicity and exposure?

### 5.4.5 Select options

The most promising options must be selected in close collaboration with management. A comparative ranking analysis may be used to prioritize opportunities for implementation. An option can be assigned scores, say from 1 to 10, based on its performance against a set of evaluation criteria. By multiplying each score by a relative weight assigned to each criterion, a final score can be arrived at. The options with the highest scores will probably be best suited for implementation. However, the results of this analysis should not be blindly accepted. Instead, they should form a starting point for discussion. All simple, cost-free and low-cost opportunities should of course be implemented as soon as possible.

## 5.5 Implementation and continuation

The objective of the last phase of the assessment is to ensure that the selected options are implemented, and that the resulting reductions in resource consumption and waste generation are monitored continuously.

### 5.5.1 Prepare an implementation plan

To ensure implementation of the selected options, an action plan should be developed, detailing:

- Activities to be carried out;
- The way in which the activities are to carried out;
- Resource requirements (finance and manpower);
- The persons responsible for undertaking those activities;
- A time frame for completion with intermediate milestones.

### 5.5.2. Implement selected options

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The company should, therefore, follow the same procedures as it uses for implementation of any other company projects.

However, special attention should be paid to the need for training staff. The project could be a failure if not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

### 5.5.3 Monitor performance

It is very important to evaluate the effectiveness of the implemented Cleaner Production options.

Typical indicators for improved performance are:

- Reductions in wastes and emissions per unit of production;
- Reductions in resource consumption (including energy) per unit of production;
- Improved profitability.

There should be periodic monitoring to determine whether positive changes are occurring and whether the company is progressing toward its targets.

### 5.5.4 Sustain Cleaner Production activities

If Cleaner Production is to take root and progress in an organization, it is imperative that the project team does not lose momentum after it has implemented a few Cleaner Production options. Sustained Cleaner Production is best achieved when it becomes part of the management culture through a formal company environmental management system or a total environmental quality management approach.

An environmental management system provides a decision-making structure and action plan to support continuous environmental improvements, such as the implementation of Cleaner Production.

If a company has already established an environmental management system, the Cleaner Production assessment can be an effective tool for focusing attention on specific environmental problems. If, on the other hand, the company establishes a Cleaner Production assessment first, this can provide the foundations of an environmental management system.

Regardless of which approach is undertaken, Cleaner Production assessment and environmental management systems are compatible. While Cleaner Production projects have a technical orientation, an environmental management system focuses on setting a management framework, but it needs a technical focus as well.

To assist industry in understanding and implementing environmental management systems, UNEP, together with the International Chamber of Commerce (ICC) and the International Federation of Engineers (FIDIC), has published an *Environmental Management System Training Resource Kit*. This kit is compatible with the ISO 14001 standard.

Like the Cleaner Production assessment, an environmental management system should be assessed and evaluated on an ongoing basis and improvements made as required. While the specific needs and circumstances of individual companies and countries will influence the nature of the system, every environmental management system should be consistent with and complementary to a company's business plan. See attached checklist in Appendix 1

## 6. RESOURCE EFFICIENT AND CLEANER PRODUCTION CASE STUDY

In a textile factory in Kenya, an RECP program was introduced which looked at identifying opportunities for CP. Recommendations from the in plant assessment included:

- Water management (Rain water harvesting)
- Energy saving (de-lamping, use of compressor hot air for humidification and installation of capacitor banks)

Following the RECP interventions identified and implemented, savings of approximately Ksh.600, 000 per month on water and Ksh.500, 000 on energy are being experienced. The factory is also considering installation of solar panels for water heating.

| Department | RECP Intervention | Savings (Kshs) |
|---|---|---|
| **Weaving** | **Energy**<br>• Lighting reduced to individual machine lighting<br>• Tapping of hot air from compressor for humidification purposes<br>• Flood lights replaced with fluorescent fittings for individual machine lighting | 500,000 |
| **Processing** | **Water**<br>• Repair of water leakages<br>• Replacement of open end steam systems in the wet ranges with closed end systems(coils) for maximum condensate collection<br>• Repaired steam and condensate leakages | 600,000 |

# 7 BARRIERS TO RESOURCE EFFICIENT AND CLEANER PRODUCTION AND HOW TO OVERCOME THEM

The foregoing chapters have established that RECP is a proactive approach to improve profitability, internal working environment and pollution and waste and emission reduction in the textile industry. Often times however, several types of barriers can block or slow the progress of a RECP programme.

Discussed here below are major barriers to be overcome for smoother RECP implementation.

1. Attitudinal barriers
2. Systemic barriers
3. Organizational barriers
4. Technical barriers
5. Economic barriers
6. Government barriers

The numbering of the barriers does not in any way suggest order of importance just as the categorization may not be reflective of prevailing circumstances in all textile processing plants. The actual combination of barriers prevailing in each textile processing plant as well as their importance may differ widely from one plant to another even though they may be operating in the same locality.

This would then mean that enabling measures will be individual plant specific and no generalized solution would be suggested to fit all players.

## 7.1 Attitudinal barriers

There is misconception that implementation of RECP costly. However, in actual fact this has been found to be not always true as in each enterprise there are RECP opportunities which can be adopted at very minimal cost. But this mind set tends to act as an attitudinal barrier to RECP implementation. RECP audits or other studies often reveal that various obstacles formulated in financial or technical terms are in fact attitudinal.

Attitudinal barriers can be classified as:

- Indifference towards housekeeping and environmental affairs
- Resistance to change

### *Indifference towards housekeeping and environmental affairs*

Good housekeeping is more a matter of culture than technique. Many small scale enterprises are set up and run by family members and lack housekeeping culture because in most cases they have no professional management systems. This ignorance and systemic failure allows continued environmental degradation by textile processing enterprises in the context of short term profit making business strategies.

### *Resistance to change*

Plant employees generally resist change that demands adoption of RECP out of fear of failure of the unknown. Many operators lack formal training and resist experimentation, fearing that any deviation from standard practice would cause them to lose control of the processes and reduce productive output. Experimentation with RECP measures is often resisted. Such reluctance to try out new practices is breeding ground for the "not me first" syndrome where people are only willing to try out an idea if it has already been successfully implemented elsewhere.

Attitudinal barriers can be overcome by ***enabling factors*** including the following:

- Early success
- Employee involvement
- Encouraging experimentation
- Publicizing early RECP successes

**Early success**:Since early success might encourage management as well as staff to continue experimentation with RECP, plant audits should first identify obvious no cost or low cost options. Such options often entail eliminating lapses in housekeeping, maintenance and process control have clear financial pay offs and are easily identified in the first joint on site visit of experts to the company.

**Employee involvement:** Involving company employees in the process of RECP options generation from an early stage increases chances of success as this helps to change their attitudes towards RECP.

**Encouraging experimentation,** especially with no and low cost options. Fear of the unknown or failure might be eliminated by specific, on the spot guidance and instructions for experimentation, e.g. modifying working procedures or choosing alternative raw or auxiliary materials. To minimize risks, experimentation should start with no and low cost practices such as improved housekeeping and process optimization, and gradually be extended on the basis of lessons learned and experience gained.

**Publicizing early RECP success:** Mills should emphasize both the financial and the environmental benefits of early RECP successes in order to create awareness among the entire workforce and to sustain commitment and involvement from key decision makers.

## 7.2 Systemic barriers

Production monitoring data and routine procedures for analysis of such data are essential to avoiding subjective and tendentious discussions in CPA process. Data collection and the development of information systems within the company are prerequisites for establishing a basis of accuracy and reliability in RECP and other operations.
The immediate financial benefits of not keeping production records might, however, often appear to outweigh the advantages of appropriate data collection and evaluation for production process optimization. Although collection of baseline data is an important starting condition for RECP activities, it is most often not necessary to do until obvious lapses in housekeeping and equipment maintenance have been eliminated. Systemic barriers can be identified as follows:

- Lack of professional management skills
- Low quality production records
- Inadequate and ineffective management systems

### Lack of professional management skills

Professional management skills can be lacking in the following areas:
*Leadership:* Small scale enterprises are run as family affairs generally. The owners and decision makers are seldom fully qualified professional managers and often fail to provide the leadership and guidance required to develop the business. Consequently, the outlook of employees is also limited to the day to day details of work with no future targets in mind.
*Supervision:* Supervisors in SSE's are often persons who have been promoted because of good performance and are not necessarily trained to perform as supervisors to instruct control and guide other workers. Operators thus view the supervisor as one of their senior colleagues instead of as a shop floor manager with direction and foresight to whom they are accountable.
*Job security:* In SSEs, job security is often more dependent on the whims of the employer than on the performance of employees, who are therefore concerned about retaining their jobs by doing what pleases the employer and would generally prefer not to risk failure in a new activity.

Even in larger units, professional managers often decline to try new things for fear of failure.

### Low quality production records

Mills often fail to maintain proper records of water, energy or material consumption, inventories of chemicals, fuels and raw materials, daily floor level log sheets of inputs, output, downtime etc. or environmental records of the quality and quality of liquid, solid and air emissions. In the absence of record keeping practices, data analysis and evaluation skills do not develop a deficiency which hampers the systematic identification of options.

### Inadequate and ineffective management systems

In the absence of a well defined management system, the lines of authority, reporting, responsibility and accountability are often unclear. Ambiguity about performance criteria encourages employees to avoid non routine work such as RECP related measures.

Flaws in management systems are particularly evident in the following areas:

*Professional upgrading of employees*: Systematic training to upgrade employee job skills is inadequate or nonexistent at many companies, where employees are thus not exposed to new industrial concepts such as RECP.

*Production Planning:* Production schedules are usually prepared on a day to day basis which hampers systematic long term work such as baseline data collection or assessment of impact of implemented measures.

### Enabling measures

The following enabling measures are proposed to deal with Systemic constraints:

- Proper documentation and plant layout
- In house RECP maintenance provisions
- Training a plant level RECP team.
- Developing simple management indicators
- Conducting a top down housekeeping drive.
- Disseminating success stories.

### Proper documentation and plant layout

Plants can improve their plant site drawings and documentation inclusive of the most recent revamping and capacity expansion projects. Such documentation serves as an excellent basis for collecting and evaluating the data needed for CPAs.

### In-house CP maintenance provisions

Generally companies with in house maintenance are a step ahead of companies that rely on outside contractors for equipment maintenance and revamping.

### Training a plant level CP team:

Conducting a training session with plant level RECP team at the start of a CPA is highly recommended. Such training should clarify the objective of RECP to reduce environmental impacts by improving productive efficiency and illustrate the benefits of planned production and the need for collecting and evaluating realistic production records. Attention should also be given to illustrating problem solving approaches preferably with examples from within the company such as lapses in housekeeping or maintenance. For best results, key decision makers including the proprietor as well as shop floor supervisor should participate.

### Developing simple management indicators

In the absence of professional management skills simple indicators should be developed to enable management and supervisors to gain control over the production processes and to minimize wastage of materials, water and energy. Indicators as simple as input material and water and energy consumption per unit of productive output might be sufficient to illustrate the benefits of improved housekeeping and initiate ongoing efforts in this field.

### Conducting a top down housekeeping drive

Housekeeping improves once key decision makers take the lead. Top management can routinely pin point lapses in housekeeping such as leaking equipment and pipes and material spills and follow up on their elimination.

### Disseminating success stories

RECP success stories can help to create and raise RECP awareness. Such accounts should be well documented with before and after financial as well as environmental data in order to pinpoint the crucial role of accurate information systems in achieving RECP. Sectoral as well as generic manuals and workshops can contribute to the dissemination of such success stories.

## 7.3 Organizational barriers

A company's organizational structure could hamper the introduction of proactive environmental management practices. It is therefore essential to assess how the tasks and responsibilities related to production management and environmental issues are divided in the company, and to suggest changes favorable to RECP. Shop floor supervisors and technical staff members should be involved in the project team, which in turn should cooperate with outside consultants.

Organizational barriers can be categorized in three separate but interrelated characteristics of industries (particularly SSIs):

- Concentration of decision-making powers
- Over-emphasis of decision making powers
- Over –emphasis on production
- Non-involvement of employees

### Concentration of decision making powers

Generally the owner is chief executive who makes all decisions, even for low cost measure. Such leaders tend to be unaware of the positive impact of motivational tools such as public recognition and awards or systems of incentives and rewards. Denied a share of decision-making responsibility, employees lack the initiative to take up new and challenging assignments such as RECP, and if a RECP team is formed, its members might not feel they have a real stake in the process.

### Over-emphasis on production

An owner's stress on production can relegate low priority on the time and effort required to conduct a CPA. In some companies, such emphasis is sustained by the fact that payment of employees is on a production basis, by which the higher the output, the higher the payment. In such a system, there is a built-in tendency to overlook RECP and housekeeping standards to boost output.

### Non-involvement of employees

Production personnel do not participate in RECP activities unless ordered to do so by the chief executive. Technical staff often faces excessive workloads and poor remuneration, especially at the junior level, which causes a high turnover rate. This condition hampers RECP efforts, as the expertise of a RECP team member often disappears when he or she departs.

*Enabling Measure*

- Mechanism to cope with organizational barriers include:
- Sharing information
- Organizing a capable project team
- Recognizing and rewarding RECP efforts
- Assigning cost to production and waste generation

### Sharing Information

Sharing cost data between managers and operators encourage operators to work more carefully with high-cost materials. Sharing information on perceived courses of equipment failure or off-specification products, among operators, and between supervisors and technical staff, facilitates problem- solving approaches to eliminate waste-generation causes.

### Organizing a capable project team

A capable well organized RECP team is capable of developing the CPA and eliminating barriers to RECP. It might be difficult to establish and effective team, however, given the widespread lack of recognition and low prioritization of RECP, the low rate of employee involvement, and the concentration of decision-making powers. A balance must be found between the preferred situation of a properly functioning project team able to develop and implement RECP on its own, and the prevalent situation, in which the organization structure inhibits the delegation of decision-making power and blocks creative problem solving. The team should also include one or several of the most concerned supervisors and operators (shoo floor workers).

### Recognizing and awarding CP efforts.

Once the team has identified and evaluated RECP opportunities, motivational schemes to encourage the team should set up, such as public recognition programmes, rewards, and publicizing early successes.
Assigning cost to production and waste generation

To expend the scope f management beyond production output to more comprehensive control over the efficiency of production, it is necessary to assign costs to the different production factors and waste streams. Normally managers can be incited to action by simple calculation of the monetary value of the raw materials, chemicals and products lost with particular waste stream.

## 7.4 Technical barriers

RECP often requires technical changes to installations, tools, input materials, auxiliaries, process and equipment. Given that RECP implementation depends upon technology, technical factors often emerge as barriers to it. The technical barriers in small and medium sized industries or enterprises (SMEs) can be categorized as follows:

- Limited Technical capabilities
- Limited access to technical information
- Technology limitations

### Limited technical capabilities

For most MEs, production ability is limited to the experience of workers, most of whom lack technical capabilities to monitor, control and improve production technology. Limitation in technical skills may take the form of:

*`Limited or non-availability of trained manpower*: lacking in-house or locally available technical personnel, many companies must depend on external expertise to perform CPA

*Lack of monitoring facilities: Lacking in-house monitoring facilities* for conducting the CPA, many companies must depend on external agencies which are scant, expensive and often based long distance away. Without adequate monitoring facilities, basic data collection suffers

*Limited maintenance facilities*: The maintenance department at SMEs is normally equipped with just enough facilities and personnel for routine maintenance, which unfortunately cannot be safeguarded in the event of equipment failure. At such companies' major maintenance jobs, such as machine overhaul, motor rewinding, and boiler cleaning, must be entrusted to external firms whose time-intensive work is an expense that represents a burden to SMEs and hinder their undertaking RECP.

### Limited access to technical information

Generally, SMEs have limited access to technical information and success stories on low resource consumption and low waste technique. Moreover there is an almost total absence of pertinent technical literature. The information available from abroad is not directly relevant or tailor made to the technical status and size of SME operations.

### Technology limitations

Technical gaps exist at SMEs in spite of modernization efforts, because most of the old conventional technology has been modified by a trial and error process without analyzing the system's basic chemistry and engineering. Such oversight has resulted in efficient, suboptimal equipment utilization and consequently, higher waste generation.

*Enabling measures*

Dairies which have an edge in overcoming technical barriers are those with staff trained in the appropriate technical skills and those which do not rely on outside sources for their fabrication Barriers to appropriate technology can be surmounted by the following measures:

- Technically skilled staff
- In-house fabrication facilities
- Disseminating success stories about RECP techniques and technologies.
- Need-based support for environment driven research and development

### Technically skilled staff

Companies with technically skilled staff members have less trouble getting started with RECP. This staffs members easily absorb the RECP concept and can transfer the general working method to the specific circumstances in their company.

### In-house fabrication facilities

SMEs have a tradition of resourcefulness, modifying old, discarded equipment to function in often new and improved ways and accumulating expertise in finding smart but simple technical fixes. The companies that operate in-house fabrication facilities (mechanical, electrical, or civil workshops) are especially well endowed with such expertise, which they can employ to identify appropriate RECP solutions or to translate improvements suggested by outside experts in such solutions.

### Disseminating success stories about RECP techniques and technologies

Disseminating success stories of RECP techniques and technologies could do a great deal to abate existing technical constraints. The publication of RECP technical manuals and the organization of workshops and seminars are useful media for disseminating such stories. To standardize the practice of successful RECP techniques and technologies within the industry, they should be dispensed to companies by intermediary organizations, such as small industries service institute, professional organizations, industry associations, and even equipment suppliers.

### Need-based support for environment driven research and development

Research and development would help to eliminate those areas in which state-of-the-art technology is not yet able to prevent environmental problems at production scales typical for SMEs.

## 7.5 Economic Barriers

Major economic barriers to RECP are:

- Prevalence of fiscal incentives that favour production quantum over production costs.
- Low prices and easy availability of raw materials
- *Ad hoc* investment policy
- High cost and low availability of capital

### Prevalence of fiscal incentives that favour production quantum over production costs

The prevailing fiscal incentives, such as concessions in excise duty, sales tax etc are mostly related to quantum of production with little or no relevance to cost of production. Entrepreneurs therefore tend to concentrate on maximizing production to derive maximum financial benefit, relegating cost-reduction exercises such as RECP to secondary levels of importance.

## Low prices and easy availability of raw materials

The impetus to identify and implement RECP measure is too often dampened by the prevailing low prices and abundant availability in many areas of natural resources such as agro residues, water and fuel. Resource scarcity, however, has become a major concern for entrepreneurs in heavily industrialized areas.

### *Ad hoc* investment policy

The ad hoc nature of investment practices in the industry is detrimental to CP in several interrelated ways:

*Limiting economic analysis to obvious direct costs and benefits:* The economics of all investments, including RECP measure, are computed mainly on the basis of direct financial returns and short term financial gains. Therefore, only increases in production capacity, reductions in the consumption of raw materials and fuels, and reductions in obvious production costs, such as the workforce, are typically accounted for. The benefits accruing form reduced electricity or pollution control costs are such savings have not been incurred. Savings derived from environmental measure are often a major part of the economic benefit of RECP measures. Failure to include such criteria in economic analysis is therefore unfavorable to the acceptance of RECP.

*Ad hoc investment criteria:* Small entrepreneurs, who are generally short of capital, tend to overlook the most attractive measures because of their higher expense, selecting instead those that are the least capital-intensive.

*Inadequate investment planning:* Investments, including those for RECP, are often made without proper planning, which may result in partial implementation. Expected results are thus not achieved causing decision makers to lose faith in the programme.

## High cost and low availability of capital

Most financial institutions are not willing to finance cost incentive RECP measure with longer (over one year) pay-back period. In countries where financing is available, interest rates are high, in the range of 15-20 per cent, making major RECP investment a challenge.

### *Enabling measures*

Mills with sound financial basis, and those which do not hesitate to implement no – and low-cost options improve their chances to overcome economic barriers. Companies can make use of the following enabling measure for overcoming economic barriers:

- Financial soundness
- Implementing financially attractive options
- Proper cost allocation and planned investment
- Long term industrial policies
- Financial incentives

### Financial soundness

Since financially sound companies are less vulnerable to economic barriers, the perceived financial soundness of a company should be used as a criterion in its selection as a demonstration of RECP investment.

### Implementing financially attractive options

Implementing cost-effective low- and no-cost RECP options can pave the way for implementing selected higher-cost options in the near future. Demonstrating the financial viability of such measure could enable a company to qualify for increasing amounts of financial assistance.

### Proper cost allocation and planned investment

Awareness of costs due to waste is a crucial starting point for any RECP programme. To illustrate the potential for savings from RECP, the company must prepare an estimate of the costs of the various components in a waste stream e.g. energy, raw materials, water, and product. Once it has allocated the costs of these components, the company can assign cost to a waste stream and estimate the savings that arise from minimizing or eliminating it. Such an exercise also identifies how much is lost through the drain.

### Long term industrial policies

Governments should avoid making frequent changes in industrial policies, a pattern which sustains short-sighted investment planning in the private sector. Long-term industrial policies would help industries merge RECP in to their investment planning and encourage them to become more competitive without artificial fiscal protection

### Financial incentives

To foster the implementation of high-cost RECP options, financial schemes that give priority to RECP proposals over end-of-pipe proposals could be developed by government or donor agencies. Such schemes, made easily accessible and procedurally simple, could have a huge impact on the capital cost and availability of RECP investments for SMEs. Governments could also institute fiscal incentives for RECP, such as a 100 per cent depreciation allowance on private RECP investments, a government purchasing policy favorable to companies committed to RECP and a concessional corporate tax for companies that perform automatic capacity enhancements.

## 7.6 Government Barriers

Government policies affect company decision-making and can thus either hamper or encourage companies to adopt RECP. Government barriers to RECP include industrial policies that discourage RECP undertakings and environmental policies that promote end-of-pipe instead of preventive solutions.

### Industrial policies

As discussed above on the economic barriers, frequently changing industrial policy is not conducive to RECP efforts. Incentive schemes, as discussed in the same section are not yet available for RECP

### Environmental policies

Regulatory authorities tend to enforce a limited set of environmental discharge standards that do not include guidelines for reducing waste generation. Entrepreneurs therefore prefer to use conventional end-of-pipe control practices that satisfy the regulatory authorities, rather than adopt RECP practices which are not necessarily recognized by these authorities

#### *Enabling measures*

Governments can adopt the following measure to foster RECP:

- Financial incentives
- Are-wide volunteer RECP groups
- Enforcement of environmental legislation

### Financial Incentives

Government could develop financial schemes that give priority to RECP proposals over end-of-pipe proposals. Such schemes, made easily accessible and procedurally simple, could have a huge impact on the capital cost and availability of RECP investments for SMEs. Governments could also institute fiscal incentives for RECP such as 100 percent depreciation allowance on private

RECP investments, a government purchasing policy favorable to companies committed to RECP and concessional corporate tax for companies that perform automatic capacity enhancements.

### Area-wide volunteer RECP groups

The government could set the stage for area-wide volunteer RECP groups and create conditions exploit their achievements.

### Enforcement for environmental legislation

If environmental laws are not enforced, entrepreneurs will not necessarily perceive the need to include environmental c concerns in their business activities.

## 8. APPENDICES

## APPENDIX 1: RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP) ASSESSMENT CHECKLIST

Company profile:

Type of activity:

### Worksheet 1: Data collection

| Essential information | Available | Not available | Team nominated to collect information |
|---|---|---|---|
| Process flow diagrams | | | |
| Production schedule-total tonnage or volume produced per year | | | |
| Operating hours | | | |
| Major raw materials Inventory | | | |
| Product inventories | | | |
| Water supply invoices for previous years. Also consider pre-treatment costs and sources (e.g. mains, surface water, ground water) | | | |

| | | | |
|---|---|---|---|
| Energy supplies invoices for previous year (e.g. electricity, LPG, natural gas or fuel oil) | | | |
| Chemicals – costs and usage for previous year (e.g. detergents , sanitizers, wastewater treatment chemicals, oils and lubricants) | | | |
| Waste water discharge invoices for previous year — volume, quality, treatment and disposal costs | | | |
| Solid waste disposal invoices for previous year — include non-recyclables and recyclables (e.g. cardboard, plastics, glass) | | | |
| **Useful additional information** | | | |
| Site plan | | | |
| Factory layout | | | |
| Environmental audit reports | | | |
| Waste water and waste water licenses | | | |

## Worksheet 2: Annual resource and waste data

| Inputs | Annual quantity | Unit charge | Annual cost (Kshs) |
|---|---|---|---|
| Raw material 1 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 2 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 3 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 4 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 5 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 6 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 7 | tonnes or $m^3$ | Kshs/unit | |
| Raw material 8 | tonnes or $m^3$ | Kshs/unit | |
| Water | $m^3$ | Kshs/ $m^3$ | |
| Packaging | Units | Kshs/unit | |

| | | | |
|---|---|---|---|
| Cleaning chemicals | L | Kshs/L | |
| Electricity | kW h | Kshs/Kwh | |
| Natural gas | MJ or Litres | Kshs/MJ | |
| Other | | | |
| **Outputs** | **Quality generated per year** | **Unit charge** | **Annual cost of disposal** |
| Waste water | $m^3$ | Kshs/ $m^3$ | |
| BOD | Kg | Kshs/kg BOD | |
| COD | Kg | Kshs/kg COD | |
| TN | Kg | Kshs/kg TN | |
| TP | Kg | Kshs/kg TP | |
| General waste | $M^3$ | Kshs/$m^3$ | |
| Recyclable waste | $M^3$ | Kshs/$m^3$ | |

## Worksheet 3: Current and target performance indicators

| | Current performance(per unit of product) | Target performance(per unit of product) |
|---|---|---|
| **Inputs** | | |
| Water | $m^3$/unit | $m^3$/unit |
| Electricity | kW h/unit | kW h/unit |
| Gas | MJ/unit | MJ/unit |
| Chemicals | kg/unit | kg/unit |
| Packaging | cartons/unit | cartons/unit |
| Other | | |
| **Outputs** | | |
| Solid waste (dumpsite) | $m^3$/unit | $m^3$/unit |
| Cardboard | $m^3$/unit | $m^3$/unit |
| Plastic | $m^3$/unit | $m^3$/unit |
| Glass | $m^3$/unit | $m^3$/unit |
| Other | kg/unit | kg/unit |
| Wastewater volume | $m^3$/unit | $m^3$/unit |
| **Wastewater quality** | | |
| COD | mg/L waste | mg/L waste |

| | | |
|---|---|---|
| BOD | mg/L waste | mg/L waste |
| TN | mg/L waste | mg/L waste |
| TP | mg/L waste | mg/L waste |

## Worksheet 4: True cost of water

| | Heated water Kshs/$M^3$ | Chilled water Kshs/$M^3$ |
|---|---|---|
| Supply cost | | |
| Heating/chilling cost | | |
| Pumping cost | | |
| Treatment cost | | |
| Discharge cost | | |
| **True cost of water** | | |

## Worksheet 5: Water consumption for individual units of operation

| Process area/unit of operation | Volume of water used weekly($m^3$) | Volume of water used yearly($m^3$) | % of total consumed |
|---|---|---|---|
| **Process area** | | | |
| **Cleaning** | | | |
| **Services** | | | |
| Boiler make-up | | | |
| Cooling tower make-up | | | |
| Domestic use | | | |
| **Total** | | | |
| **Actual volume purchased** | | | 100 |
| **Variance/unaccounted** | | | |

## Worksheet 6: Energy consumption

| Form of energy | Annual usage | Annual usage(common unit) | Annual cost(Kshs) | % of total energy cost |
|---|---|---|---|---|
| Electricity | kW h | MJ | | |
| Natural gas | $m^3$ | MJ | | |
| LPG | MJ | MJ | | |
| Fuel oil | kg | MJ | | |
| Coal | | | | |
| Other | | | | |

| Energy Type | **Conversion Factor** |
|---|---|
| **Electricity** | 3.6 MJ/kWh |
| **Natural gas** | 39.5 $MJ/m^3$ |
| **Fuel oil** | 43.1 MJ/kg |
| **Coal** | 30.7 MJ/kg |
| **Steam** | 2.8 MJ/kg |

## Worksheet 7: Electricity consumption

| Process area | Equipment | No. of items | Rating(kW) | Capacity/ load | Hours of use(h/day) | Estimated Consumption(kW h/year) | Subtotal (kW h/ year) | % of total |
|---|---|---|---|---|---|---|---|---|
| *e.g. Coldroom1* | *Atlas Copco compressor* | *1* | *30* | *90%* | *24* | | | |
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| **Total** | | | | | | | | |
| **Actual electricity consumed** | | | | | | | | |

## Worksheet 8: Solid waste audit

| Waste steam | Source and cause of waste | Generation rate and pattern | Storage pre disposal | Service contractor and disposal location | Cost of Disposal(Kshs) | Comments |
|---|---|---|---|---|---|---|
| *e.g. plastic packaging* | *batch preparation* | *1.0 $m^3$ per day* | *15 $m^3$ skip* | | *15/$m^3$* | *Investigate plastic recycling company* |
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## Worksheet 9: Waste water charges

| Component | License limit | Average load(mg/L) | Average daily load(kg) | Council charge | Actual cost of discharge(Kshs) |
|---|---|---|---|---|---|
| BOD | mg/L | | | Kshs/kg | |
| COD | mg/L | | | Kshs/kg | |
| TN | mg/L | | | Kshs/kg | |
| TP | mg/L | | | Kshs/kg | |
| Other | mg/L | | | Kshs/kg | |
| Volume | $m^3$ | | | Kshs/$m^3$ | |
| | | | | **Total cost** | |

## Worksheet 10: Wastewater audit

| Waste stream | Source and cause of waste | Generation rate and pattern | Mass load | Comments |
|---|---|---|---|---|
| *e.g. product tank wastewater* | *cleaning of product tanks* | *daily* | *500 mg/L BOD* | *Consider clean-in-place system* |
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## Worksheet 11: Potential RECP opportunities

| Opportunity<br><br>Potential resource saving Passed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Water** | **Energy** | **Packaging** | **Chemical** | **Solid waste** | **Waste water** | **Other(e.g. labour, maintenance)** | **preliminary evaluation Yes/No** |
| *e.g. Reduce timers on filling machine*<br><br>*cleaning cycle* | | | | | | | | |
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## Worksheet 12: Economic evaluation of RECP opportunities

| | |
|---|---|
| Costs of implementing the opportunity<br><br>• Estimate the likely cost of equipment and installation and any other up-front costs associated with the change?<br>• Estimate any on-going costs such as running costs, maintenance, materials, labour etc. (for a 12-month period).<br><br>**Total costs (a + b)**<br><br>**Savings from implementing the opportunity**<br><br>• Determine the possible savings in terms of materials, water, energy, treatment, and disposal etc. (for a 12-month period)?<br><br>• Is the change likely to lead to increased sales of current or new products? What would be the likely range (for a 12-month period)?<br><br>Quantify any other associated costs or benefits.<br><br>**Total savings (c + d + e)**<br><br>**Payback period**<br><br>Payback period in months = $\frac{\text{Total cost}}{\text{Total savings}} \times 12$ months | |

## Worksheet 13: Summary of RECP opportunities

| RECP opportunity | Capital cost | Annual saving (resources) | Annual saving(Kshs) | Payback(months) | Implement (date) | Responsible person(s) |
|---|---|---|---|---|---|---|
| **Water** | | $m^3$ | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Energy** | | kWh/MJ | | | | |
| | | | | | | |
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| | | | | | | |
| **Packaging** | | $m^3$ | | | | |
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| | | | | | | |
| **Chemicals** | | L | | | | |
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| **Solid waste** | | $m^3$ | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Wastewater** | | $m^3$ | | | | |

## APPENDIX 2: GLOSSARY

**BAT**-best available technology and best available techniques (from an environmental viewpoint

**Best practice**: the practice of seeking out, emulating and measuring performance against the best standard identifiable

**BOD**-Biological oxygen demand a measure of the quantity of dissolved oxygen consumed by microorganisms' due to breakdown of biodegradable constituents in wastewater

**CFC**- chloroflouro carbon, an ozone depleting substance

**CIP**- cleaning in place or circulation of a cleaning solution through or over the surface of production equipment.

**COD**-Chemical Oxygen Demand is a measure of the quantity of dissolved oxygen consumed during chemical oxidation of waste water.

**Eutrophication**- High growth of algae causing poor penetration of light in the water and high oxygen consumption

**ISO 14001**- International Standard Iso14001 Environmental Management System specification with guidance for use under International organization for standardization

**NOx** -Nitrogen oxides; covers both $NO_2$ (nitrogen dioxide) and NO (nitrogen monoxide)

**PAHs** – Poly Aromatic Hydrocarbons, Occur in flue gases from combustion of fuel

**PU** -A measure of pollution units used in The Netherlands (1 p.u. equals the organic pollution of wastewater from one person)

**PVC**- Polyvinyl chloride, a commonly used plastic that some are carcinogenic

**RECP**-Resource Efficient and Cleaner Production

**SOx**-Sulphur oxides; covers the various forms of gaseous sulphur oxide compounds found in combustion gases.

## ANNEX 3: RESOURCES AND REFERENCES:


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# ABOUT LAKE VICTORIA ENVIRONMENTAL MANAGEMENT II (LVEMPII)

## 1.0 LVEMP II BACKGROUND

LVEMP II aims at contributing to the East African Community's (EAC) Vision and Strategy Framework for Management and Development of the Lake Victoria basin of having a prosperous population living in a healthy and sustainably managed environment providing equitable opportunities and benefits. The phase I of the Project runs in the period 2009-2013 and the second phase may last possibly to 2017 and will contribute to broad-based poverty alleviation and improvement of shared natural resources of the Lake Victoria Basin (LVB).

### 1.1 LVEMP II Specific Objectives

a) Improve collaborative management of trans-boundary natural resources of LVB for the shared benefits of the EAC Partner States.
b) Reduce environmental stress in targeted pollution hot spots and selected degraded sub-catchments to improve the livelihoods of communities who depend on the natural resources of the LVB.

### 1.2 LVEMP II is regarded as an instrument to:

1. Achieve stress reduction outcomes in priority hotspots i.e. the project's interventions are expected to have measurable impact on the estuaries, bays, and gulfs due to point source pollution control.
2. Lay a foundation for the long-term program for sustainable improvement in the environmental status and water quality.

## 2.0 CLEANER PRODUCTION SUB-COMPONENT OF LVEMP II

The sub-component on Promotion of Cleaner Production Technologies seeks to reduce point sources of pollution from industry, by supporting the uptake of cleaner technologies and techniques in industry so as to rehabilitate priority degraded sub-catchments of Lake Victoria. The Cleaner Production project seeks to increase the competitiveness of the Lake Basin industries by reducing wastes, and negative impacts whilst enhancing raw material utilization efficiencies by deploying cleaner technologies and techniques.

The project targets at building the capacity of industry through education, training and a "learning-by-doing" cleaner production audits. This is in line with the region's Vision Strategy that is looking at shifting industrial transformation from regulatory intervention to promotion of voluntary initiatives. The vision strategy specifically aims at (i) building the capacity of enterprises to formulate and implement pollution prevention strategies and programmes that will improve their competitiveness and productivity (ii) building up the capacity of the region to formulate and manage an overall strategy for industrial development within the framework of an open economy (iii) strengthening the capability of both the private and public sector players to manage development resources within the region leading to a quality environment and employment creation for poverty reduction.

## 2.1 Long Term Impact

The Cleaner Production project is expected to contribute towards the long-term impact of sustainable industrial development in the Lake Victoria Basin. This shall be realized through increased industrial productivity as well as by reduced industrial pollution loadings into the lake.

## 2.2 Project Development Objective (PDO)

The PDO of this project is "to promote the Utilization of Cleaner Production Technologies by industries in the Lake Victoria Basin"

The success of this Project Development Objective shall be evaluated through the following:

» Adoption of integrated environmental management by industries and switch to Cleaner Production technologies and techniques
» Reduced point source pollution from industries and enhanced efficiency of resource utilization

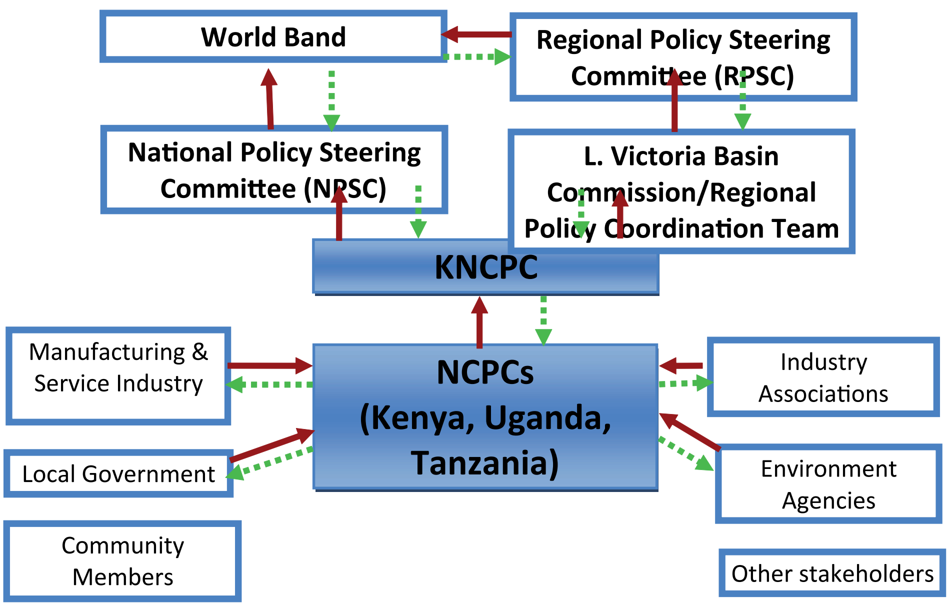
The interventions of the Cleaner Production sub-component shall be on:
Component 1: The promotion of education, information dissemination, and training on resource efficient and cleaner production

Component 2: Promotion of cleaner production demonstration projects in enterprises through rapid and detailed in-plant assessments

## 3.0 INFORMATION FLOW

## 3.1: Information Flow Chart

Information flow and reporting hierarchy shall flow as below indicated.




KNCPC: Kenya National Cleaner Production Centre
NCPC: National Cleaner Production Centres

## 4.0 DATA COLLECTION

The sub-component shall collect both raw and historical data from industry pertaining to wastewater quantity and quality (BOD, COD, TN, and TP), solid waste volumes, production levels, energy and water consumption. These shall be used to determine the baseline performance levels before cleaner production intervention. Measurements of the same indicators shall be made after the CP intervention and improvement levels determined. All industries operating in the Lake Basin are expected to participate in the program.

## 5.0 THE MAIN INDICATORS FOR PROJECT PERFORMANCE

The principal indicator of the project success will be the enhanced readiness of industry and municipalities to develop and ultimately invest in cleaner production. It is recognized that the decision to invest will not depend exclusively on economic considerations, but will also consider company culture and social aspects. That is why awareness sessions to remove "myths" on cleaner production have been designed. In addition, the regional policy initiatives and of Governments will create a favourable working environment within which industry can implement cleaner production.

Specific indicators for success of the sub-component are:

i. Number of industries and technical staff trained in Cleaner Production from industry
ii. Number of industries implementing Cleaner Production Programs
iii. Number of Cleaner Production options identified and being implement
iv. The quantities of pollution reduced in tons per year and wastewater quality released
v. The efficiencies realized by industry in material, water and energy consumption per ton of product
vi. Public and industry awareness levels of the benefits of pollution prevention and waste minimisation and are involved with the project
vii. Indicators of formulated and implemented Cleaner Production strategies
viii. Development and implementation of national and regional Cleaner Production action plans

## 6.0 DATA ANALYSIS & REPORTING

Data collected from industry shall be written in a uniform report comprising the following:

- Rapid assessment: Short analysis, which assesses the quality of the crucial processes, pollution intensities, material and energy flows in order to identify the potentials for resource efficiency and cleaner production (RECP).
- Detailed assessment: Systematic modeling of production processes, identification of RECP options for waste reduction, technical and financial evaluation and implementation.
- EST transfer: Identification and evaluation of both front-and end-of-pipe technology transfer and development including support for the preparation of technology investment projects. This shall enable the implementing partners to provide technical assistance to industry to develop effluent discharge management plans and environmental management systems to enable industry clusters/sectors comply with regulations & standards.

## 7.0 DISSEMINATION, FEED BACK AND REVIEW MECHANISM

The economic and environmental benefits realized from the Cleaner Production interventions in industry shall be disseminated in workshops, through newsletters, print media, the regional RECP network and websites. The regional communication strategy shall also guide on other appropriate channels for disseminating the information.