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The impact of textile industry on China's environment

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Similar to other industrial activities, the textiles and clothing sector plays a significant role in China's escalating economy. Although the industry brings economic benefits to the country, the processes involved in textile production result in unprecedented environmental problems. It is well known that the textile industry has a negative impact on the environment. However, it remains unclear how this impact is generated. This article evaluates the relationship between China's textile industry and the environment using a quantitative framework. The rationale behind the negative impact of the expanding textile industry on China's environment is discussed. Furthermore, suggestions will be given to address the problems associated with the textile industry in China.

Keywords: China; textile industry; environment; pollution

Introduction

Because of the open-door policy in late 1979, the world has been amazed by China's elevated economy, whose growth rate is matched by no other country (Cheung 1998). China has gradually transformed from an agricultural economy to an industrial economy. The World Bank revealed that China's GDP rose sharply in the first three quarters of 2007, and achieved an overall 11.5% growth in the same year. As shown from the World Bank statistics, China's average income was USD 2025 in 2006 compared with USD 293 in 1985 (Kahn and Yardley 2007). Among the myriad commodities produced in China, textiles and clothing are some of the main income-generating sources.

According to the World Trade Organisation (WTO 2008), China is now the world's largest exporter of textiles and clothing. As shown in Figure 1, within the period of 1990–2007 (the latest year), the value of textile exports has increased significantly from over USD 7.21 billion to USD 48.68 billion. This is an increase of over six-fold in less than two decades (WTO 2008).

In addition to the prominent impact that the textile export value has on China's economy, the industry employed about 10 million people in 2006, which accounted for over 13% of the country's total labour force. As illustrated in Figure 2, the number of textiles and clothing enterprises has climbed steadily in the past seven years (National Bureau of Statistics of China 2006). On the basis of the factors described earlier, it can be concluded that the textiles and clothing industry has had a remarkable contribution to the growth of China's economy.

With the consecutive soaring double-digit growth rates in recent fiscal years, the escalating industrial development places China's environment under pressure (Kahn and Yardley 2007). There is a great deal of literature describing how the economic activities result in a negative impact on this historic land (Smil 1996, The World Bank 2001, Chai 2002). The direct relationship between economic development and environmental deterioration has been investigated. Smil (1996) stated that environmental exploitation is related to economic expansion because all economies are just a part of the world's ecosystem. It is devastating for a country to continue prospering without considering environmental problems (Fang 2001). Assessed by the World Bank, China's economy has a high energy intensity and inadequate energy efficiency. The country uses 10–20% more energy than other Organisation for Economic Co-operation and Development countries for the numerous industrial processes (The World Bank 2008). As China relies on coal as the main energy source, the energy consumption per unit commodity production is unexpectedly high. This causes serious environmental problems in the country (Murray and Cook 2002). On top of the issue, China's environmental legislation does not play a significant role in impeding the problem. For example, China's automobile standards fall behind the European countries by 10 years (The World Bank 2008). Factories are able to discharge up to 36 billion tons of untreated industrial wastewater

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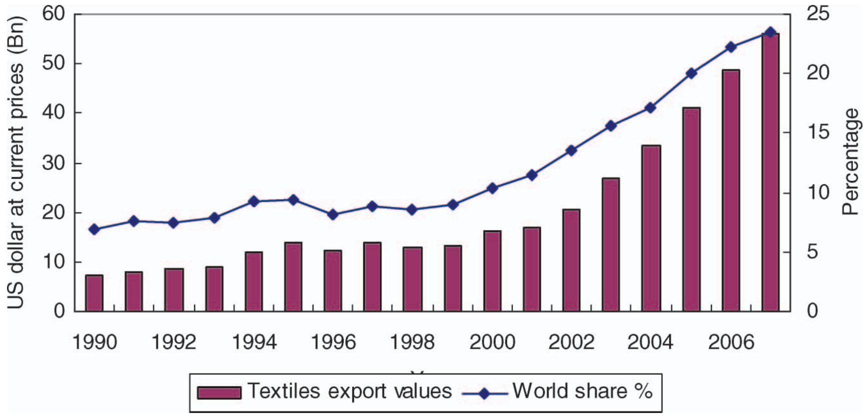

Figure 1. China textile export performance (1996–2007).

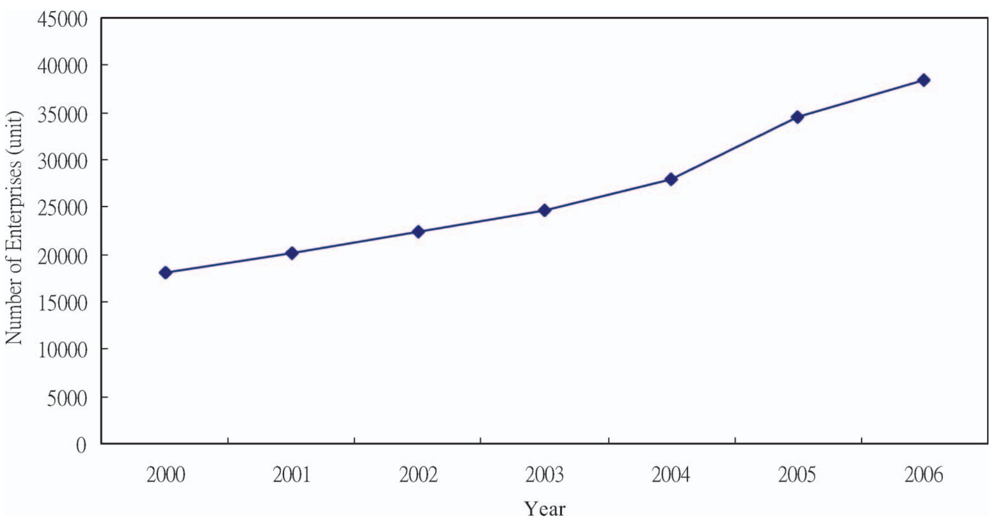

Figure 2. Number of all state-owned and non-state-owned above designated size (all state-owned and non-state-owned industrial enterprises above designated size refer to all state-owned industrial enterprises plus the non-state-owned industrial enterprises with an annual sales income of over 5 million yuan) textiles and clothing enterprises (2000–2006).

into rivers, lakes and coastal waters annually. Only a small portion of household and industrial waste is treated before being released into the streams, lakes, ponds and local irrigation ditches. Therefore, Murray and Cook (2002) concluded that 'nearly half of the country's rivers and over 9% of its urban water resources have been polluted to some extent'. China's seven major watersheds, which are Huaihe River, Haihe River, Liaohe River, Songhuajiang River, Changjiang (Yangtze) River, Zhujiang (Pearl) River and Huanghe (Yellow) River, have all been reported as seriously polluted.

One might have anticipated that with the main economic activities in China having shifted from capital-intensive heavy industries to labour-intensive light industries and the service sector (Jahiel 2007), the environmental problem would not be overwhelmingly serious. However, Chai (2002) presented an important discussion on this industrial shift. He proposed that the core axis on solving the green issues is not simply a change from one sector to another; it is about the scale or extent of overall economic growth (Jahiel 2007). Thus, the scale of light industry is booming in a way that it worsens China's environment at an unexpected pace. The textile sector, which is considered to be a good example of light industry, can reflect this phenomenon. In the present work, a quantitative framework has been applied to point out the negative impact brought by the textile industry.

Textile industry and China's environment

For years, as one of the largest and highly diverse industries in China, the textile industry has boosted

China's economy and employed a large amount of labour. It can be seen from Figure 3 that the respective production of chemical fibre, yarn and cloth has noticeably increased over the past decade.

Among these three textile products, chemical fibre has the largest growth. In 1997, the total national output of chemical fibre was around 4.7 million tons and it jumped to 24 million tons in 2007. Conceivably, the textile industry has been prospering in the last 15 years. Although the yearly elevating output has helped China to be one of the world's leading textile producers, the deteriorating environmental impact led by this industrial activity should not be neglected.

From 1997 to 2006, the volume of polluted water, gas and solid waste discharged from China's textile industry increases can be observed in Figures 4 and 5. However, data on solid waste discharge (Figure 5) for year 2003 would require further verification. The deviation from the general increasing trend might be because of the missing of data during the SARS outbreak in the same year. Consequently, one can expect that all production stages involved in textile manufacturing have led to many environmental issues such as water pollution, air pollution, poor water quality, water shortage, waste disposal, noise pollution, degradation of croplands and grasslands and so on. Large amounts of water, energy, chemicals and colouring auxiliaries are required in textile manufacturing. Specifically, water is extensively involved in each processing stage. Therefore, water pollution is a serious issue in textile manufacturing. A textile factory in Beijing, China can be an example to illustrate how polluted water is generated throughout a dyeing process. The bath ratio of a beck dyeing machine can be as high as 1:20–1:25 (Visvanathan *et al.* 2000a). This means that 1 unit weight of goods requires 20–25 unit weight of bath to process whereas the liquor ratio of the modern dyeing machine can be as low as 1:3. This inferior technology makes water consumption per unit of production about five per cent higher than that in developed countries. Other major sources of water pollution are the low dye uptake of local made dyes, poor wastewater control and shortfall of effective management in the dyeing process. Thus, when compared with developed countries, the sewer discharge per product is nearly doubled in China, and these problems make the textile industry one of the major contributors of industrial sewage (Cheng and Shen 2004).

The expanding scale of the textile industry worsens the situation. As shown in Figure 2, the number of textile firms increased significantly over the past 16 years. For the existing textile enterprises, most of them are small firms. This occurs because the textile sector provides relatively easy start-up opportunities compared with other sectors because financial and technical requirements are low (Jahiel 2007). However, these small firms have a great impact on the environment because of their limited investment in superior machinery and technology. Moreover, because of China's lack of 'rural environmental protection personnel ... the development of these small firms is difficult to regulate' (Jahiel 2007). Cheng *et al.* (2004) presented in-depth research on the impact of China's admission to the WTO and the environment. After China became a member of the WTO in 2001, foreign investment in these small plants increased. The advantage is that this increases the capital of the small plants which allows improvement to the technological level of the industry. Foreign investment also imposed a positive effect on the firms in regulating the environmental policy (Cheng and Shen 2004). However, these benefits cannot compensate for the loss brought to the environment by the industry (Jahiel 2007).

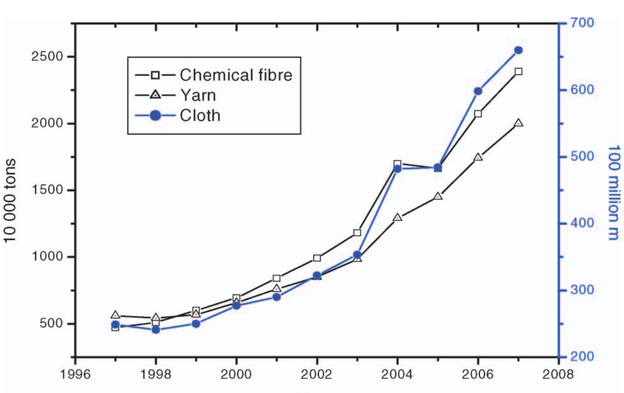

Figure 3. Output of China's major textile products (1997–2007).

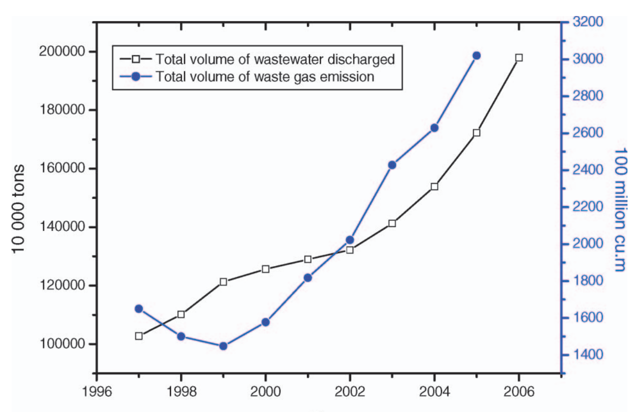

Figure 4. Total volume of wastewater and waste gas produced from China's textile industry (1997–2006).

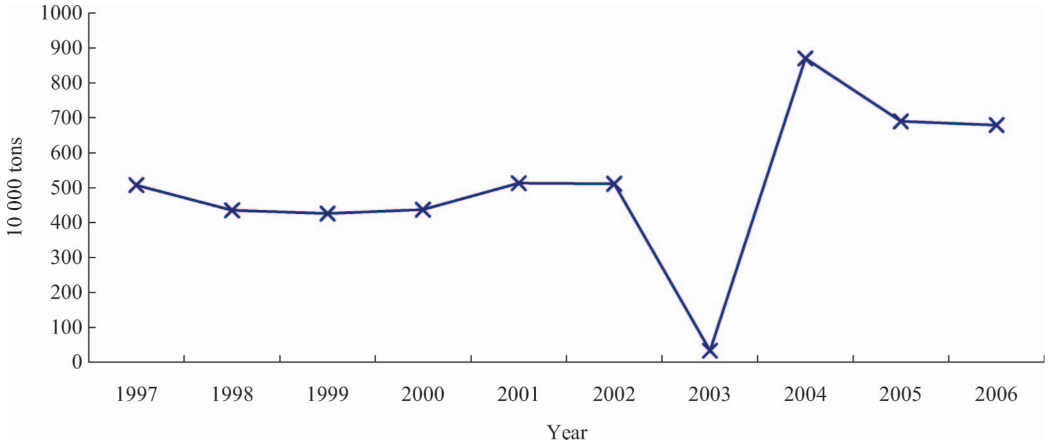

Figure 5. Total volume of solid wastes generated by China's textile industry (1997–2006).

Much research has been done to tackle the environmental issue in textile manufacturing (Chen and Burns 2006, Nieminen *et al.* 2007). For example, cotton is modified genetically so that less pesticide is required (Phipps and Park 2002); new technologies in machinery are adopted to make energy use more efficient and numerous labelling systems are used to regulate the emissions of the textile industry. However, the expected advantages from these practices remain to be fully realised (Jahiel 2007).

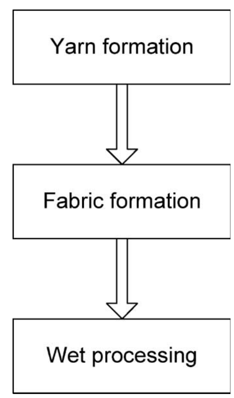

Figure 6. Typical textile processing flow chart (USA Environmental Protection Agency 1997).

Environmental impact of textile manufacturing

All industrial activities unavoidably cause pollution. The textile industry, which is reported to have a significant impact on the environment, is no exception (Visvanathan *et al.* 2000b, Bide 2001, Chavan 2001, Joshi 2001, Shroff 2001). This section discusses an example of how a typical textile production process (as shown in Figure 6) can impose an adverse effect on the environment.

Jiangsu Province is adopted as an example to discuss the impact of textile manufacturing on the environment. Situated along the east coast of China with the famous Changjiang (Yangtze) River running through its southern part, Jiangsu Province is one of the major provinces which is recognised for its economic and industrial development (Hong Kong Trade Development Council Research Department 1996). The GDP of Jiangsu Province rose sharply from CNY 668 billion in 1997 to CNY 2574 billion in 2007. Jiangsu enjoys a rich number of natural water resources. There are different sizes of lakes and river branches spread throughout the whole province, such as Changjiang (Yangtze) River, Huaihe River, Yihe River, Taihu Lake, Hongzehu Lake, Gaobaohu Lake, Grand Canal and Chuanchanghe River. With Jiangsu's superior geographical location, many foreign investors are attracted to start up their businesses there. Among the vast varieties of commodities produced in Jiangsu, textiles is one of the prospering industries. In 2006, the respective amount of chemical fibre, yarn and cloth produced in Jiangsu was around 33, 22 and 16% of the total national output. However, the rapid development of the textile industry has resulted in an unfavourable impact on Jiangsu's environment. For example, the ongoing use of DDT in cotton fields seriously polluted the Changjiang (Yangtze) River (Yang *et al.* 2008), the water quality of Taihu Lake has deteriorated since the 1980s economic development (Shen *et al.* 2001), an abnormally high concentration of nitrogen was found in the Kuihe River (Wu *et al.* 2007). With statistics collected from the National Bureau of Statistics of China (2006), the following section shows how textile production brings an enormous amount of pollutants to the province's environment.

Yarn formation

There are variations among the operations of yarn formation from factory to factory. Figure 7 outlines the most common steps involved in cotton yarn production.

There has been concern about the effects of cotton cultivation on the environment because of the consumption of chemicals and pesticides (Bide 2001, Fang 2001). Before raw cotton is transported to the plant, the fibres are squashed into a package to provide easy transport. This process, which is called baling, produces noise and dirt (Slater 2003). In turn, breaking apart the bales to loosen the compacted fibres and remove impurities produces a large amount of dust and air pollution. After opening, processes such as blending, carding, combing, drawing and roving follow. The environmental consequences from these stages are noise, air, water and land pollution (Slater 2003). Spinning is the final step in yarn production to assemble the fibres by inserting twists onto the yarn. However, noise and a large amount of dust are produced during spinning. The dust generated is a mixture of traces of fibres as well as organic and inorganic particles such as leaf, husk fragments and sand (Kane 2001). Other than cotton, synthetic fibre is also a common material which is made from the extraction of petroleum (a non-renewable and non-biodegradable resource) (Fang 2001, Chen and Burns 2006). During the production of synthetic fibres, nitrous oxide which depletes the Earth's ozone layer is emitted, causing an undesirable load on the environment. For the production of wool fibres, an energy intensive process called scouring is required to remove the impurities from the wool. This operation results in a large amount of hot water that contains non-ionic detergent and builders to emulsify the wool grease (Walters *et al.* 2005).

Another source of pollution is the use of lubricating oils which are applied to the spinning machines to prevent fibre loss and allow high speed processing (Walters *et al.* 2005). This creates polluted effluent. Energy consumption is also an environmental issue in the spinning mills. Because of machinery operation and air conditioning (a stable indoor condition is critical for spinning to ensure a reduction in yarn breakage and an increase in productivity), more than 90% of the energy used in a spinning mill is electricity (Cooper 1978).

The environmental impact of yarn formation can be illustrated in Figures 8–10. In Jiangsu, the total value and production of chemical fibre rose steadily over the past 6 years. From Figures 9 and 10, it can be seen that polluted solid waste increases with the output of chemical fibre. This is the same with the recent years of wastewater discharged (2003–2006). However, there is no apparent trend for gas pollutants. Although chemical fibre production has brought economic

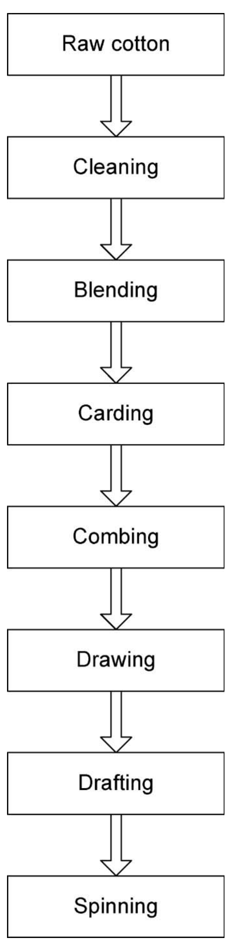

Figure 7. General steps in cotton yarn formation (Shamey and Hussein 2005).

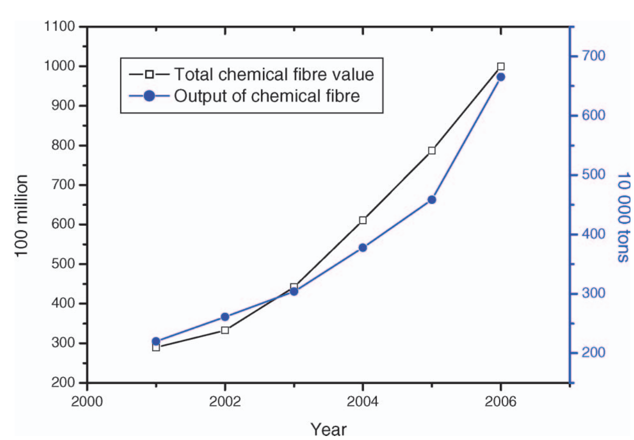

Figure 8. Total value and output of chemical fibre of Jiangsu, China (2001–2006).

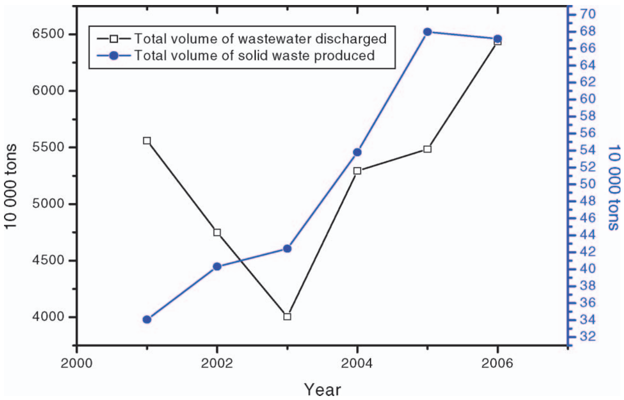

Figure 9. Total volume of polluted water and waste produced from the Jiangsu chemical fibre factories (2001–2006).

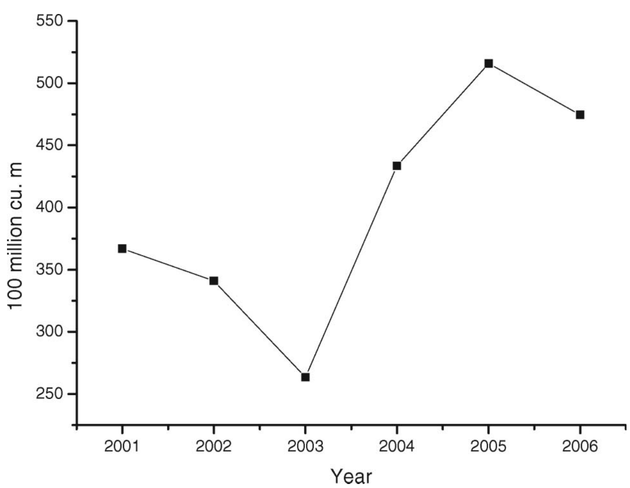

Figure 10. Total volume of waste gas produced from the Jiangsu chemical fibre factories (2001–2006).

benefits, this has a negative effect on the environment which might lead to unsustainable development of the industry.

Fabric formation

The following is a diagram (Figure 11) that shows the steps in producing fabrics.

Knitting and weaving are the two traditional fabric production methods. A large amount of energy is consumed because of machine size and complexity. Weaving involves synchronisation between looms, sheds and shuttles. This mechanical action generates an undesirable amount of noise (Slater 2003). Noise control is a common issue in textile production because many machines operate simultaneously (Noweir and Jamil 2003). Excessive machine noise is disturbing because it can cause serious and permanent damage to

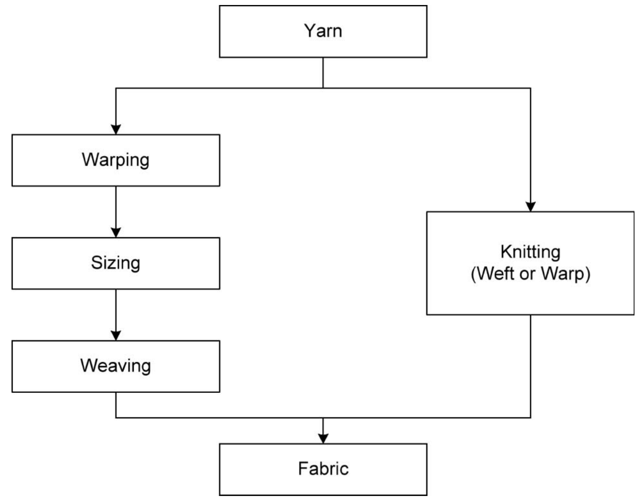

Figure 11. Steps in fabric formation (Shamey and Hussein 2005).

hearing and it is an unpleasant source of annoyance to those inside and outside the plant (Klyszejko 1980). The average noise levels in a textile plant ranges between 70 and 110 dB. Weaving has a relatively high noise output when compared with other operations. It can be as high as 110 dB. According to Talukdar (2001), different loom types and machine rates can significantly affect the noise level. Therefore, better control of the width of the weaving machine can efficiently decrease the noise level in a mill.

To prevent the breakage of yarn, sizing is applied to the warp yarn which makes it more slippery, supple and stronger (Walters *et al*. 2005). However, the sizing agent, which is made up of either natural or synthetic materials, is washed in the subsequent steps causing water pollution. Therefore, 70% of the chemical oxygen demand load of a mill finishing woven fabric comes from desizing liquor (Walters *et al*. 2005).

As one of the major textile production provinces, Jiangsu's environment is also threatened by the industrial activities. However, this monetary income has a negative effect on the environment. Figures 12 and 13 reveal that the total textile value and output of both yarn and cloth have been increasing in the past six years. At the same time, yarn and cloth production releases a large amount of pollutants into the environment. As a great amount of water is required to process the fabric, Jiangsu has discharged up to 480 million tons of wastewater in 2006 as shown in Figure 14. This situation is worsening each year as the textile output increases. Although there is no direct relationship between the level of output and the polluted emission of solid waste and gas as in Figure 15, the level of pollutants has brought severe environmental problems as mentioned earlier.

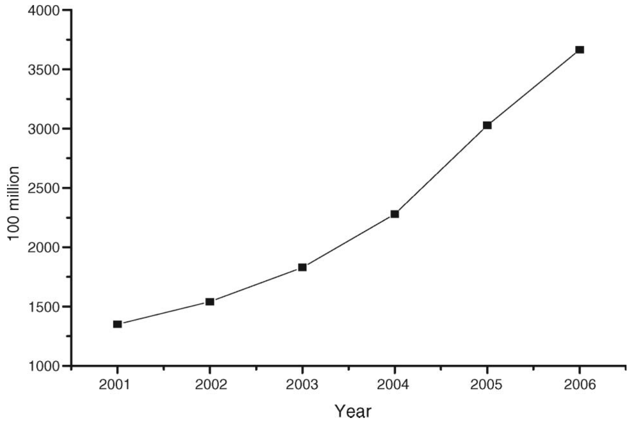

Figure 12. Total textile value of Jiangsu (2001–2006).

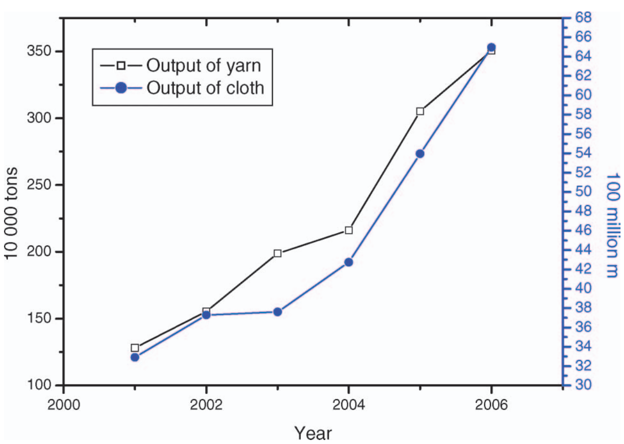

Figure 13. Output of yarn and cloth of Jiangsu, China (2001–2006).

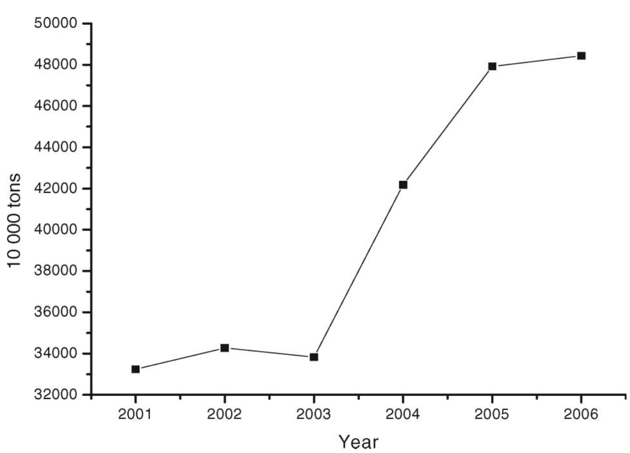

Figure 14. Total volume of polluted water discharged from the Jiangsu textile factories (2001–2006).

The variation of Figure 15 could be because of the use of a different quality of raw material which could have affected the behaviour of the end product as well as the pollutant emitted. Therefore, the textile industry not only brings wealth to the country, it also brings soaring pollution problems.

Wet processing

Because of the variety of steps potentially implemented in wet processing, Figure 16 discusses the most

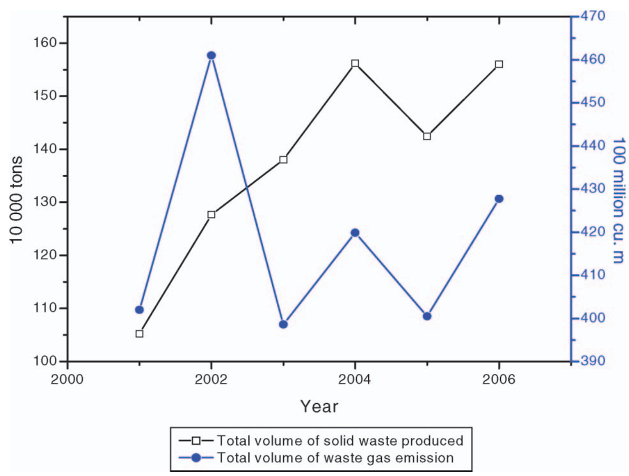

Figure 15. Total volume of polluted waste and gas produced from the Jiangsu textile factories (2001–2006).

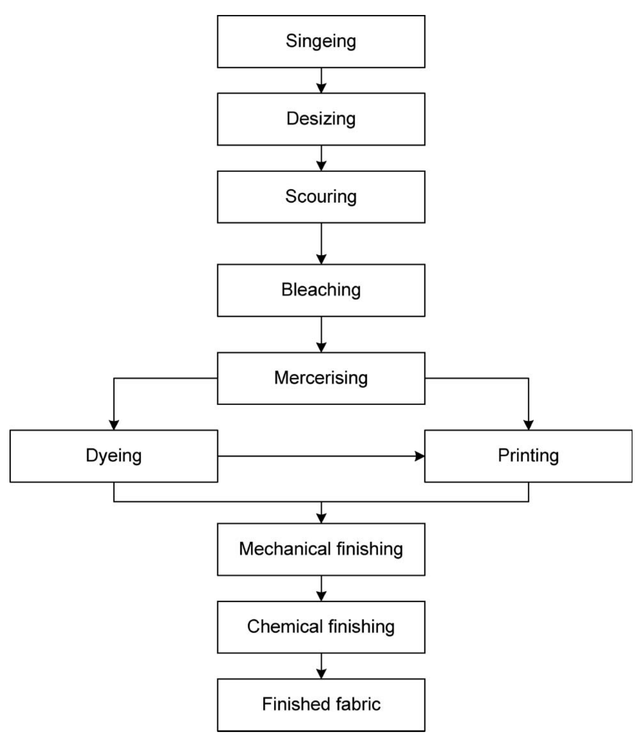

Figure 16. Steps in wet processing (Shamey and Hussein 2005).

common steps that are carried out in the manufacturing plants.

The wet processing stage, which gives the final product some desired properties, is further divided into three phases: pre-treatment, colouring and finishing. Some of these steps may be optional depending on the type of fabric being manufactured (USA Environmental Protection Agency 1997). The consequence of each process could be of 'varying severity' (Tobler-Rohr 2000, Fang 2001, Mirata 2001). Water is a necessary means for the wet processing treatment. The amount of water consumption per operation varies with the type of fibre being processed as well as the chemicals being used (Deo and Wasif 1998). On average, the textile industry uses 50–150 litres of water per kg of textile material (Achwal 1998). Scouring and bleaching are parts of the pre-treatment stage which clean the fabric to achieve a desirable degree of whiteness. These operations can remove the auxiliary chemicals left by the prior fabric production which increase a better dye take-up and give a more consistent result (Walters *et al*. 2005). The solution used during the bleaching process contains chemicals such as hydrogen peroxide, chlorine dioxide and hypochlorite. The effluent emitted from scouring is a toxic liquid containing sodium hydroxide, which is high in pH value and can poison aqueous species (Slater 2003). Fabrics obtain shades and colours by dyeing and printing and water acts as the solvent to fix dyes onto the fabrics. Water consumption varies between processes and the machines used. For example, there are numerous dyeing techniques under the two main principles in dyeing: discontinuous and continuous/semi-continuous dyeing. Each of the dyeing method has a different liquor ratio which determines the water consumption used per kg of fabric (Lacasse and Baumann 2004). Normally it is around 30–60 litres of water for 1 kg of fabric (Deo and Wasif 1999). There are chances that the colouring agent is not picked up by the fibres. Hence, the dyestuff is left behind in the dye liquors and gives colour to the wastewater (Slater 2003). Figure 17 summarises the water consumption of each stage in wet processing. It can be seen that dyeing can take up as much as 46% of the total water usage. The common factors for indicating water pollution in the textile industry are pH, total alkalinity, total dissolved solids, suspended solids, biochemical oxygen demand, chemical oxygen demand, chlorides, sulphates calcium, magnesium, sodium and potassium (Jhala *et al*. 1981). The characteristics of each sample of wastewater are determined by the range of chemicals, dyes and auxillaries used.

In addition, finishing gives fabrics the required functional properties such as water resistance, durability, anti-shrinking and softening. All these desirable characteristics are created with the consumption of many chemicals and auxiliaries which not only affect the environment but also human health (Mirata 2001, Lacasse and Baumann 2004). A case was reported that excessive formaldehyde which was found on some easy-care garments irritated human skin (Sewekow 1996). Therefore, the potential harm that textile products impart to our health and the environment cannot be ignored.

Air pollutants generated from other textile finishing processes are originated mainly from the pathways such as singeing, thermofixing, thermosoling and impregnating (Lacasse and Baumann 2004). Figure 18 shows that weaving and wet processing combined account for over 50% of the energy consumption in the textile processing. High energy consumption is equivalent to a higher emission of greenhouse gas during the electricity generation (Visvanathan *et al*. 2000a).

Other textile manufacturing processes

According to the USA Environmental Protection Agency (1996), high-temperature drying and curing ovens are the most common source of air emissions in a textile operation. All these high temperature operations are needed to process the coating of textile materials. Heat-setting and thermofixation, with typical operation temperature ranging from 250 F to 400 F, emit a

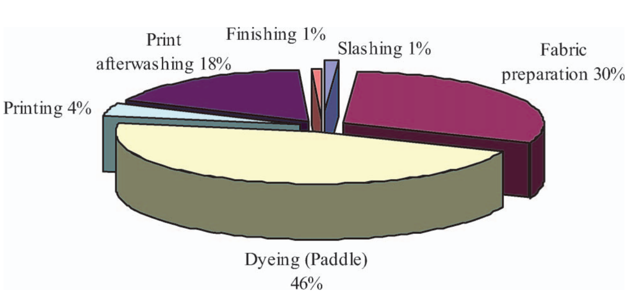

Figure 17. Water consumption in textile wet processing.

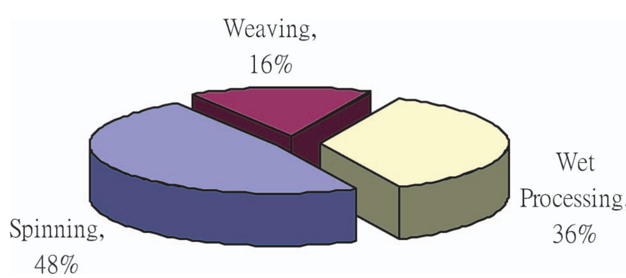

Figure 18. Energy consumption in textile processing (Visvanathan *et al*. 2000a).

certain level of air particles and waste detergent which can cause air and water pollution (Slater 2003). Apart from the production stages mentioned previously, transportation of goods between production sites also emits air pollutants such as sulphur dioxide, carbon monoxide and carbon dioxide. Therefore, the environmental problems created by transportation should not be neglected. Some textile materials emit formaldehyde and amine odours which irritate the human respiratory system (USA Environmental Protection Agency 1996). Moreover, the overall textile production produces miscellaneous solid wastes such as selvage trimmings, fly ash, aluminium cans and wooden pallets. This makes textile manufacturing a source of the waste stream (USA Environmental Protection Agency 1996).

Conclusion

From the previous sections, it can be concluded that the significant impact of textile industry on China's economy and environment is acknowledged. As both environment and economy are of equal importance to a country's stable development, this has left China with a dilemma. The Chinese Government has to opt for a method to promote sustainable development in all types of industrial activities and at the same time, not impede the country's competitiveness and income. With the prominent role the textile industry has on China's economy, closing down textile plants is not a proper strategy in environmental protection. This will seriously affect the international textile trade. In 2005, the Chinese Government formulated the 11th Five-Year Programme for the National Economic and Social Development. It called for a plan which put pollution prevention and control at top priority. The document proposed to strengthen the environmental monitoring and supervision system through law enforcement. It can be enhanced by economic means such as tax collection and fine payment. To emphasise environmental protection, a series of guidelines on industrial waste treatment, greenhouse gases reduction and urban garbage disposal were thus distinguished. To combat the dyeing problems specifically, the Chinese Government has reduced the tariff rate on imported dye from 10.8% to 6.5% in 2008 (Cheng and Shen 2004). This promotes the use of the more eco-friendly imported dyes which can in turn help to reduce industrial wastewater pollution. In terms of technological level, the Chinese textile industry lagged far behind the developed countries. Therefore, the proposal stressed the importance of improving the manufacturing technology, especially in constructing more advanced wastewater treatment facilities. Although, the result of the Five-Year Plan are yet to be seen, there is a need to develop an evaluation method so as to regulate the overall environmental performance of the textile industry.

There is a number of evaluating methods to assess the performance of the textile industry. According to the statistics from the WTO (International Trade Centre UNCTAD/GATT 1994), a new eco-label is introduced into the market every month. The number of eco-labels has largely increased since its introduction in 1978 (Fang 2001). With the rising number of new standards, manufacturers are obliged to comply with different requirements of buyers and suppliers around the globe. There is a profusion of studies identifying the problems in eco-labelling (International Trade Centre UNCTAD/GATT 1994, McCarthy and Burdett 1998, Kalliala and Nousiainen 1999, Gallastegui Galarraga 2002, Nieminen *et al.* 2007, Amstel *et al.* 2008). Because of limited resources, plants may find it hard to have the products manufactured according to the designated methods and standards. Moreover, the complexity of a textile production process increases the difficulty to achieve optimum results under these eco-regulations. One common approach of eco-labelling is sending products to laboratories for harmful substance testing. However, this product-oriented nature could not guarantee satisfaction of other products which are also produced by the same plant (International Trade Centre UNCTAD/GATT 1994). Other than random checking, the production process has to be monitored in a continuous way. Kalliala and Nousiainen (1999) pointed out that different eco-labels have their own course in setting criteria and limits which confuse people by their discrete principles and make comparison difficult for unambiguous product and process. Another hindrance is that the scheme could only ensure that a limited proportion of products carried the label (International Trade Centre UNCTAD/GATT 1994). Besides, the eco-labels are treated as marketing instruments with little factual and technical information. Customers might regard the labels as fraudulent claims (International Trade Centre UNCTAD/GATT 1994).

As manufacturing varies among industries, an environmental performance indicator is needed to assess the manufacturing performance of a textile plant (Ren 2000, Tyteca *et al.* 2000). Several studies attempted to develop a framework for environmental performance indicators (Young *et al.* 1996, Olsthoorn *et al.* 2001). However, the context is ambiguous to apply in the textile industry. It is not appropriate to assume all businesses are facing a similar environmental problem. Even though some of them are based on the textile industry, the indicator is not detailed enough to present a comprehensive view on environmental friendly manufacturing (Ren 2000). Ren (2000) proposed that it is necessary to set a consistent framework and criteria when developing an index. This can ensure a uniform output for each indicator and favour better communication among the plant, local authorities or even international stakeholders. Olsthoorn *et al*. (2001) agreed that the indicators available nowadays should be standardised so that the information collected is of interest to both the internal and external stakeholders.

Furthermore, although the textile industry is promoting eco-textiles through the use of harmless materials, the necessary result will not be realised if green manufacturing and management systems are ignored. However, Cao (2007) stated that few attempts have studied the performance evaluation and eco-efficiency improvement in this industry. Yet, the existing environmental performance indicators are mostly too general and would probably overlook the manufacturing process. There is a need to develop an industry specific assessment method to manage its green issues. Thus, it is imperative for the textile industry to develop its own management approach which is suitable for its own practices and technologies. When an appropriate green policy complements green technology, not only the environment can be improved but also other industries will be motivated to follow this approach.

References

Achwal, W.B., 1998. Water/energy management and packing. *Colourage*, 45 (10), 36–38.

Amstel, M.V., Driessen, P., and Glasbergen, P., 2008. Eco-labeling and information asymmetry: a comparison of five eco-labels in the Netherlands. *Journal of Cleaner Production*, 16 (3), 263–276.

Bide, M., 2001. Textiles and the environment. *Industrial Fabric Products Review*, 78 (1), 50–53.

Cao, J., 2007. Measuring green productivity growth for China's manufacturing sectors: 1991–2000. *Asian Economic Journal*, 21 (4), 425–451.

Chai, J., 2002. Trade and the environment: evidence from China's manufacturing sector. *Sustainable Development*, 10 (1), 25–35.

Chavan, R.B., 2001. Indian textile industry-environmental issues. *Indian Journal of Fibre and Textile Research*, 26, 11–21.

Chen, H.L. and Burns, L.D., 2006. Environmental analysis of textile products. *Clothing and Textiles Research Journal*, 24 (3), 248–261.

Cheng, L. and Shen, X., 2004. Textiles. *In*: China Council for International Cooperation on Environment and Development, ed. *An environmental impact assessment of China's WTO accession: an analysis of six sectors*. Manitoba: International Institute for Sustainable Development, 179–206.

Cheung, K.C., 1998. Environmental challenges facing China. *In*: J.G. Jabbra, O.P. Dwivedi, and International Association of Schools and Institutes of Administration, eds. *Governmental response to environmental challenges in global perspective*. Amsterdam: IOS Press, 157–166.

Cooper, S.G., 1978. *The textile industry: environmental control and energy conservation*. New Jersey, USA: Noyes Data Corporation.

Deo, H.T. and Wasif, A.I., 1998. Green technology in textile processing. II. Bleaching of polyester/cotton fabric. *Indian Journal of Fibre and Textile Research*, 23 (4), 257–260.

Deo, H.T. and Wasif, A.I., 1999. Green technology in textile processing. III. Eco-friendly dyeing of cotton goods. *Indian Journal of Fibre and Textile Research*, 24 (1), 58–63.

Fang, K., 2001. *Fang zhi pin sheng tai jia gong ji shu*. Beijing, China: Zhongguo fang zhi chu ban she.

Gallastegui Galarraga, I., 2002. The use of eco-labels: a review of the literature. *European Environment*, 12 (6), 316–331.

Hong Kong Trade Development Council Research Department, 1996. *Jiangsu sheng shi chang bao gao*. Hong Kong: Hong Kong Trade Development Council.

International Trade Centre UNCTAD/GATT, 1994. *Textiles and clothing: an introduction to quality requirements in selected markets*. Geneva, Switzerland: ITC.

Jahiel, A.R., 2007. China, the WTO, and implications for the environment. *In*: N.T. Carter and A.P.J. Mol, eds. *Environmental governance in China*. Abingdon: Routledge, 162–181.

Jhala, P.B., Vyas, M.M., and Subrahmanyam, K., 1981. *Water and effluents in textile mills*. Ahmedabad, India: Ahmedabad Textile Industry's Research Association.

Joshi, M., 2001. Environmental management systems for the textile industry: a case study. *Indian Journal of Fibre and Textile Research*, 26 (1), 33–38.

Kahn, J. and Yardley, J., 2007. As China roars, pollution reaches deadly extremes. *The New York Times*, 26 August 2007.

Kalliala, E. and Nousiainen, P., 1999. Life cycle assessment of textiles from fibres to end-use and the environmental index model for textiles and textile services. *In*: *79th world conference of the textile institute*, 10–13 February, Chennai, India, 307–319.

Kane, C.D., 2001. Environmental and health hazards in spinning industry and their control. *Indian Journal of Fibre and Textile Research*, 26 (1–2), 39–43.

Klyszejko, C., 1980. *Noise in the cotton and allied fibres, flax and jute sectors*. Manchester, UK: Shirley Institute.

Lacasse, K. and Baumann, W., 2004. *Textile chemicals: environmental data and facts*. Berlin, Germany: Springer.

McCarthy, B.J. and Burdett, B.C., 1998. Eco-labelling and textile eco-labelling. *Review of Progress in Coloration*, 28, 61–70.

Mirata, M., 2001. Use of environmental performance indicators to promote cleaner technologies in small and medium sized cotton textile wet processing industry. *In*: *7th European roundtable on cleaner production*, 2–4 May 2001, Lund, Sweden, International Institute for Industrial Environmental Economics.

Murray, G. and Cook, I.G., 2002. *Green China: seeking ecological alternatives*. London, UK: Routledge.

National Bureau of Statistics of China, 2006. *China statistical yearbook* [online]. Available from: http://www.stats.gov.cn [Accessed 11 June 2008].

Nieminen, E., *et al*., 2007. EU COST action 628: life cycle assessment (LCA) of textile products, eco-efficiency and definition of best available technology (bat) of textile processing. *Journal of Cleaner Production*, 15 (13–14), 1259–1270.

Noweir, M.H. and Jamil, A.T.M., 2003. Noise pollution in textile, printing and publishing industries in Saudi Arabia. *Environmental Monitoring and Assessment*, 83 (1), 103–111.

Olsthoorn, X., *et al.*, 2001. Environmental indicators for business: a review of the literature and standardisation methods. *Journal of Cleaner Production*, 9 (5), 453–463.

Phipps, R.H. and Park, J.R., 2002. Environmental benefits of genetically modified crops: global and European perspectives on their ability to reduce pesticide use. *Journal of Animal and Feed Sciences*, 11 (1), 1–18.

Ren, X., 2000. Development of environmental performance indicators for textile process and product. *Journal of Cleaner Production*, 8 (6), 473–481.

Sewekow, U., 1996. How to meet the requirements for eco-textiles. *Textile Chemist and Colorist*, 28 (1), 21–27.

Shamey, R. and Hussein, T., 2005. *Critical solutions in the dyeing of cotton textile materials*. Manchester, UK: Woodhead Publishing Limited.

Shen, J., *et al.*, 2001. Environmental issues of lake Taihu, China. *Hydrobiologia*, 581 (1), 3–14.

Shroff, J.J., 2001. Textiles and ecology. *Colourage*, 48 (7), 17–18.

Slater, K., 2003. *Environmental impact of textiles: production, processes and protection*. Cambridge, UK: Woodhead Publishing Limited.

Smil, V., 1996. *Environmental problems in China: estimates of economic costs*. Hawaii, USA: East-West Center.

Talukdar, M.K., 2001. Noise pollution and its control in textile industry. *Indian Journal of Fibre and Textile Research*, 26 (1–2), 44–49.

Tobler-Rohr, M.I., 2000. Life cycle assessment of a cotton fabric in textile finishing. *In*: *Fiber society spring conference*, 17–19 May 2000, Guimares, Portugal, The Fiber Society.

Tyteca, D., *et al.*, 2000. Environmental indicators in industry – the mepi experience. *In*: *6th conference of the international society for ecological economics*, 5–8 July, Canberra, Australia.

USA Environmental Protection Agency, 1996. *Manual: best management practices for pollution prevention in the textile industry* [online]. Environmental Protection Agency. Available from: http://www.p2pays.org/ref/02/01099.htm [Accessed 5 June 2008].

USA Environmental Protection Agency, 1997. *Profile of the textile industry* [online]. Environemtnal Protection Agency. Available from: http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/textilsn.pdf [Accessed 2 June 2008].

Visvanathan, C., Kumar, S., and Han, S., 2000a. Cleaner production in textile sector: Asian scenario. *In*: *National workshop on sustainable industrial development through cleaner production*, 12–13 November, Colombo, Sri Lanka.

Visvanathan, C., *et al.*, 2000b. Energy and environment indicators in the Thai textile industry. *In*: *Proceedings of the third Asia-Pacific conference on sustainable energy and environmental technologies*, 3–6 December, Hong Kong, World Scientific.

Walters, A., Santillo, D., and Johnston, P., 2005. *An overview of textiles processing and related environmental concerns* [online]. Greenpeace Research Laboratories. Available from: http://www.greenpeace.to/publications/textiles_2005.pdf [Accessed 4 June 2008].

World Bank, 2001. *China: air, land, and water: environmental priorities for a new millennium*. Washington, DC: The World Bank.

World Bank, 2008. *The world bank* [online]. Available from: www.worldbank.org [Accessed 11 June 2008].

World Trade Organization, 2008. *WTO trade statistics* [online]. Available from: www.wto.org [Accessed 11 June 2008].

Wu, Y.G., *et al.*, 2007. Effectiveness of riverbank filtration for removal of nitrogen from heavily polluted rivers: a case study of kuihe river, xuzhou, jiangsu, China. *Environmental Geology*, 52 (1), 19–25.

Yang, X.L., *et al.*, 2008. Dicofol application resulted in high DDTs residue in cotton fields from northern jiangsu province, China. *Journal of Hazardous Materials*, 150 (1), 92–98.

Young, W., *et al.*, 1996. Defining environmental performance indicators: an integrated framework. *Business Strategy and the Environment*, 5 (2), 69–80.