Compact detergents in China – A step towards more sustainable laundry
A Life Cycle Assessment of four typical Chinese detergents

INTRODUCTION

The Chinese detergent industry has been in rapid development since the 1980s. In the period from 1980 to 2010, the annual production of synthetic detergents has increased more than 20 times from 393,000 tons in 1980 to more than 8 million tons in 2010 (2). Meanwhile, as the consumer demand for detergent performance grows, so do expectations for improved environmental performance. Previous studies have illustrated that there may be significant environmental benefits from a change towards the compacted detergents. The Chinese Cleaning Industry Association (CCIA) has identified representative detergent varieties listed for a standard and a compacted powder detergent, as well as for a standard and a compacted liquid detergent (1). The environmental impacts of a change towards the compacted detergents are studied using life cycle assessment (LCA). The study is intended in accordance with ISO 14040. Environmental benefits are found in all studied impact categories. The system boundaries of this study are defined as the processes in the product chain from raw material extraction to final disposal are included. The study is based on LCA principles, where all significant processes in the product chain from raw material extraction through production and use to final disposal are included. The LCA is performed according to the ISO 14040 standards (ISO, 2006) (7) and environmental modeling is facilitated in the LcA tool (ISO, 14040) (8) and environmental modeling is facilitated in the SimPro 7.3.3 LCA software. The system boundaries of this study are defined as the processes in the product chain from raw material extraction through production and use to final disposal are included. The LCA is performed according to the ISO 14040 standards (ISO, 2006) (7) and environmental modeling is facilitated in the SimPro 7.3.3 LCA software. The system boundaries of this study are defined as the processes in the product chain from raw material extraction through production and use to final disposal are included. The LCA is performed according to the ISO 14040 standards (ISO, 2006) (7) and environmental modeling is facilitated in the SimPro 7.3.3 LCA software. The system boundaries of this study are defined as the processes in the product chain from raw material extraction through production and use to final disposal are included. The LCA is performed according to the ISO 14040 standards (ISO, 2006) (7) and environmental modeling is facilitated in the SimPro 7.3.3 LCA software.

KEYWORDS: Environmental assessment; laundry detergent; compaction; greenhouse gas emissions; wastewater quality.

Abstract

Chinese production and consumption of household detergents are growing rapidly, causing increased environmental impacts. The Chinese Cleaning Industry Association (CCIA) has identified representative ingredients lists for a standard and a compacted powder detergent, as well as for a standard and a compacted liquid detergent (1). The environmental impacts of a change towards the compacted detergents are studied using life cycle assessment (LCA). The study is being peer reviewed in accordance with ISO 14040. Environmental benefits are found on all studied impact categories. One conclusion is that the only situation where the environmental impacts from compaction are negative is if consumers do not reduce dosage but keep applying the same amount of detergent to their washing machine.

Since then, the Chinese Cleaning Industry Association (CCIA), the most important stakeholder of the Chinese detergent industry, has launched an ambitious promotion plan for compact detergents. The first generation compact powder detergent label was launched in 2009, followed by an updated label in 2012. At the same time, cooperation across the value chain on promoting compact detergents in China was initiated among raw material suppliers, detergent manufacturers and retailers. We have studied the environmental impacts of two typical compaction cases where we compare two compact detergents - one powder and one liquid - with two standard detergents (2). The results are used to put current efforts in perspective and identify possible opportunities for future environmental development of the industry.

LCA TEST METHOD

The study is based on LCA principles, where all significant processes in the product chain from raw material extraction through production and use to final disposal are included. The LCA is performed according to the ISO 14040 standards (ISO, 2006) (7) and environmental modeling is facilitated in the SimPro 7.3.3 LCA software. This study compares the environmental impacts of four typical Chinese detergents: two are standard detergents, and another two are compact detergents. The function unit in this study refers to one wash in an average Chinese washing machine (~ 2.5 kilograms of clothes).

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- Standard powder detergent: One dosage is 50 grams per wash and the surfactant content is 16.5%.
- Compact powder detergent: One dosage is 25 grams per wash and the surfactant content is 19.5%.
- Standard liquid detergent: One dosage is 40 grams per wash and the surfactant content is 17%.
- Compact liquid detergent: One dosage is 20 grams per wash and the surfactant content is 30%.

The wash performance of the two powder detergents is assumed to be comparable, and the wash performance of the two liquid detergents is assumed to be comparable. This assumption is based on the experience of CCIA’s members. No wash performance tests were performed in the current study. Note that the quality of the liquid and the powder detergents are not assumed to be comparable due to differences in consumer preference. Powder detergents are perceived as easier to use and having a milder function. Therefore comparison should only be made between standard and compacted detergent for powder and liquid respectively, and not between powder detergent and liquid detergent (see Figure 1). The system boundaries of this study are defined as the processes in the product chain from raw material extraction through production and use to final disposal are included. The LCA is performed according to the ISO 14040 standards (ISO, 2006) (7) and environmental modeling is facilitated in the SimPro 7.3.3 LCA software.

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### Environmental Assessment

Environmental impact categories and resource consumption impact categories included in this study are listed below:

- Global warming (g CO₂ equivalent)
- Acidification (mg SO₂ equivalent)
- Nutrient enrichment (mg PO₄₅ equivalent)

Toxicity from the entire life cycle is excluded because the available data basis is considered incomplete, and because Pant et al. (2004) (10) identified that the most significant toxic impacts from detergents are linked to the wastewater from the washing process. Depending upon where in China the laundry wash takes place, this wastewater may be released into the environment with little or no treatment. In this study, the environmental impacts of this wastewater were measured based on a screening method, calculation of critical dilution volume (CDVtox). CDV offers a way to understand the potential toxicity of cleaning products and toxic chemicals on the water system. CDV measures how much water is needed to dilute a substance so the toxicity of the dilution is below acceptable boundaries.

### RESULTS

Characterized results of the environmental assessment are shown in the table 3 and 4 as net reduction. The studied compaction cases result in net reduction for all impact categories and environmental indicators. The environmental benefits from compaction of the powder detergent under study are larger than the benefit from compaction of the liquid detergent under study with regard to global warming, acidification, and nutrient enrichment. With regard to agricultural land use as well as to toxicity, the benefits from compaction of liquid detergent are larger.

Compaction of the detergents results in savings of 31 g CO₂ per wash. If Chinese households shifted to compacted detergents, this would be a 0.5 million tons CO₂ reduction which equals the annual emissions of 750,000 cars or supplying electricity for 500,000 average Chinese families.

Figure 2 shows the ingredients and processes that contribute to the greenhouse gas emissions (GHGs) for the four detergents under study.

Environmental benefits of compaction are mainly driven by saved ingredients and less need for packaging and transport. The saved ingredients contribute to environmental benefits in two ways: First the energy to produce the saved ingredients is saved, and second there is less organic material (surfactants and enzyme products) in the wastewater which is degraded with release of CO₂.

Surfactants are the largest source of gHg emissions from all types of detergents as they account for the gHg from production as well as most of the GHG emissions from degradation of organic content. In powder detergents, reduction of surfactants could be as important as 30% of GHGs coming from builders in the standard powder. Formulation processes (mixing and drying of detergent) are of minor importance to the overall result and are hardly visible in Figure 2. Overall, this figure suggests that reformulation is the strongest way for detergent industry to find environmental improvements.

### Sensitivity Analysis

The environmental impacts from producing detergent ingredients are estimated based on EcoInvent (2010) (8). However, many of these data were collected in the 1990s in European research studies and may not provide a fair picture of production in China today. We found data on current Chinese production of benzene and ethylene oxide (which are inputs to the production of surfactants, as well as data on sodium carbonate and sodium sulphate in CLCD (2012) (9)). Using these instead of the data from EcoInvent (2010) (8), the gHg emissions from producing surfactants (2012) (9) are found for the other environmental impacts. The used input data are found for the other environmental impacts. The used input data are found for the other environmental impacts.

### Conclusions and Recommendations

Compaction proves to be one important way for the detergent industry to reduce environmental impacts. We recommend that the industry continues their efforts to introduce compacted detergents.

A number of sensitivity analyses were performed showing that the conclusions of the study are robust, although magnitudes of environmental advantages are subject to much variation and uncertainty. However, compaction may lead to environmental disadvantages in one situation: If consumers do not reduce dosage but keep applying the same amount of detergent to their washing machine. We recommend that the industry provides sufficient incentive to the consumer to use the recommended dosage by pricing, dosing instructions or by supplying dosing devices that avoid incorrect dosing.

### Building Reduction

Build reduction offers the largest environmental benefits with regard to greenhouse gas emissions.

### Contribution to global warming

When consumers dose correctly or do not reduce dosage of compacted detergent accordingly.

### Environmental impacts from ingredients to two alternative compact powder formulations

All data are per one wash. Differences due to rounding.

### Environmental impacts from three alternative compact powder formulations

All data are per one wash. Differences due to rounding.

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All data are per one wash. Differences due to rounding.
Choice of surfactant greatly impacts the results as the individual surfactants may have significantly different impacts, especially on wastewater quality (aquatic toxicity). We recommend further studies or collaboration with wastewater treatment plants to increase knowledge on how detergents impact wastewater treatment plants and the receiving environment.

Enzyme products, due to their high weight efficiency, may provide a good formula design opportunity for further environmental improvements. We recommend that the industry continues LCA activities to ensure that the compacted detergents that are promoted supply the highest possible environmental benefits.

REFERENCES AND NOTES

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