# Reducing the Water Footprint of the Global Cotton-Textile Industry: Efficient Use of Advanced Dyeing Chemicals, Technologies and Wastewater Treatment in Pakistan

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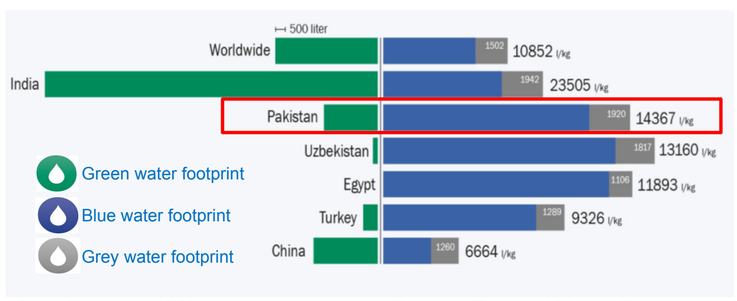
## INTRODUCTION

German demand of cotton-textile products is responsible for substantial water consumption and wastewater effluents in Pakistan. The water footprint has widely been accepted as an indicator to assess the water efficiency of the cotton-textile production process. Methodologically, green (rain), blue (surface and groundwater), and grey (wastewater-based) footprints are calculated.

Within this collaborative project InoCottonGROW Pakistani and German research and industry partners intend to contribute to sustainable water resources management in Pakistan by implementing various case studies and demonstration projects. Here different approaches are shown to reduce water consumption and effluents along the cotton-textile value chain by the use of efficient process chemicals, advanced technologies and suitable wastewater treatment methods in textile dyeing processes.

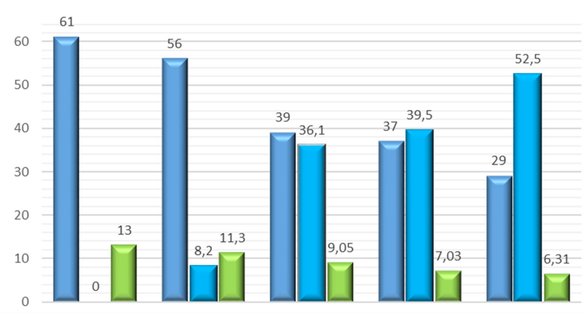



Source: Chapagain et al. 2006

*Cotton-Textile Water Footprint*

## RESULTS OF INDUSTRIAL REACTIVE JET DYEING PROCESSES IN COLOUR BLACK

Source: http://www.styletextile.com




| | Fabric: 100 % Cotton single jersey, unbleached | P0 | P1 | P2 | P3 | P4 |
|---|---|---|---|---|---|---|
| | Recipe/Auxiliaries | STANDARD, STYLE three baths | STANDARD, imitated three baths | 1st improvement three baths | 2nd improvement three baths | 3rd improvement one bath |
| | Liquor ratio | 1:6 | 1:6 | 1:5 | 1:5 | 1:6 |
| | **Water use (l/kg)** | **61** | **56** | **39** | **37** | **29** |
| | **Reduced water use (l/kg)** | **0** | **5** | **22** | **24** | **32** |
| | **Water saving** | **0** | **8,2 %** | **36,1 %** | **39,5 %** | **52,5 %** |
| | **Process time (h:min), measured** | 11:00 | 11:27 | 9:00 | 6:45 | 6:25 |
| | **Process time (h:min), calculated** | 13:00 | 11:30 | 9:05 | 7:03 | 6:31 |

- Process P0: Dyed onsite at project partner STYLE TEXTILE (Lahore/Pakistan)
- Process P1 – P4: Dyed at project partner Thies Textilmaschinen in cooperation with CHT(chemicals)

TEXTILMASCHINEN Thies

CHT SMART CHEMISTRY WITH CHARACTER.

**Water use**: reduction > 29 l/kg appear possible

**Water saving**: > 50 % appear possible

**Process time**: reduction > 40 % (as side effect)

## TEST PARAMETERS FOR THE COMPARIBILITY OF DYEING RESULTS AS AN INDUSTRIAL QUALITY CONTROLLING TOOL

| Trial | Colourimetry ΔE* | Lightness | Saturation | Hue | Strengh of colour (%) | Colour Fastness Perspiration ff DIN EN ISO 105-E04 (grade) | Domestic and commercial laundering ff EN ISO 105-C06:2010-A1M (grade) |
|---|---|---|---|---|---|---|---|
| P1 | 1,5 | darker | less saturated | greener | 104,7 | 5 | 5(5-4) |
| P2 | 3,2 | darker | less saturated | redder | 138,97 | 5 | 5 |
| P3 | 2,7 | darker | less saturated | greener | 132,88 | 5 | 5 |
| P4 | 1,3 | darker | more saturated | redder | 101,32 | 5 | 5 |

*ΔE value (CMC/D65) related to standard trial P0

- Due to a ΔE > 1 and differences in lightness, saturation, hue, strength of colour, all dyeing trials are not equal to black colour of trial P0.
- The colour fastness tests to perspiration and domestic laundering almost achieve best possible results.

## RESULTS OF COLOUR FASTNESS TO RUBBING TESTINGS

| Dyeing Trial | TEST ff EN ISO 105-X12:2016 (Grade) w/o rinsing Dry | Wet | after rinsing once (liquor ratio according to dyeing process) 40 °C Stainer Dry | 40 °C Stainer Wet | ΔE value compared to trial w/o rinsing | 40 °C washing machine Dry | 40 °C washing machine Wet | ΔE value compared to trial w/o rinsing | 60 °C Stainer Dry | 60 °C Stainer Wet | ΔE value compared to trial w/o rinsing |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | (4-)5 | 2 | 5 | 3-4 | 0.16 | 3-4 | 3 | - | 5 | 3 | 0.09 |
| P2 | (4-)5 | (1-)2 | 5 | 3 | 0.64 | (4)-5 | 2-3 | 0.65 | 4-5 | (2-)3 | 0.33 |
| P3 | 5 | 1-(2) | 5 | (2)-3 | 0.54 | (4)-5 | (2)-3 | 0.28 | (4)-5 | 3 | 0.76 |
| P4 | (4-)5 | (1-)2 | 5 | 3-(4) | 0.50 | 5 | (2)-3 | 0.50 | 5 | 3 | 0.74 |

**Results**: All four trials show first poor results in fastness to wet rubbing testings.
**Solution:** A further rinsing at 40 °C or 60 °C (under lab conditions) causes acceptable results regarding industrial requirements. The small variation of the ΔE value (CMC/D65) which is < 1 indicates a negligible change of the starting colour.

## NEXT STEPS IN INOCOTTONGROW

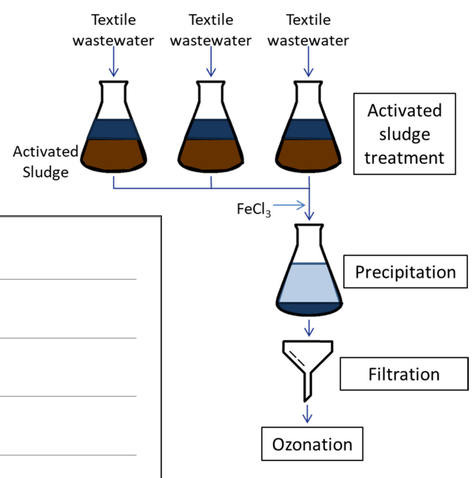
**Dyeing recipes and processes:** need further adjustments to make sure colour and testings will also fulfil industrial requirements.

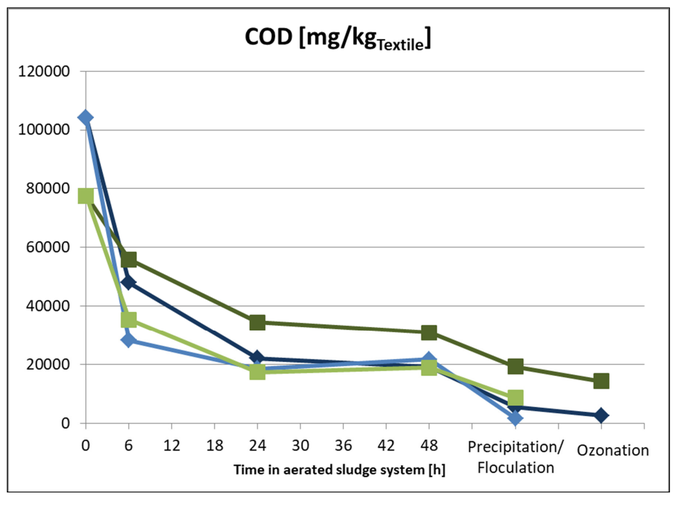
**Onsite trials:** The optimized processes will be demonstrated on full-scale dyeing machines at STYLE TEXTILE to proof their water- and energy saving potential.

**Wastewater treatment:** Two wastewater treatment pilot plants will be operated at textile mills in Pakistan to demonstrate efficient and cost-effective technologies to reduce wastewater emissions.

**Water footprint:** The gathered data will be added to the InoCottonGROW database and thereby help to calculate the water footprint of the Pakistani textile industry.

## LABORATORY-SCALE WASTEWATER TREATMENT




Measured parameters:
- Conductivity, pH
- COD, $BOD_5$
- NH4-N, NO3-N, TNb
- PO4-P,
- $SAK_{436}$,
- TOC and DOC

- Wastewater from trial P1
- Wastewater from trial P2 (optimized process)
- Wastewater from trial P1 mixed with municipal wastewater (50/50 Vol%)
- Wastewater from trial P2 mixed with municipal wastewater (50/50 Vol%)

**Results:** The experiments suggest that implementing the optimized process in a textile finishing plant will only improve wastewater emissions in cases where no wastewater treatment plant is in operation (most Pakistani finishing plants).
At plants with operating wastewater treatment, the measured parameters suggest no improvements or even higher emissions in the optimized than in the standard process for producing the same amount of textiles.

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