Determination of heavy metal and physicochemical parameters in textile finished products

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ABSTRACT Textile industry is one of the most important manufacturing sectors for the development of a society such as in Pakistan. Cotton crop is the main raw material used in the sector for the production of textile fiber in the form of clothes, woven or non-woven. The aim of this study is to investigate the heavy metal contents and physicochemical parameters of the textile finished materials. The concentrations of heavy metals in 10 different textile fibers of different colors, collected from local markets in Hyderabad city, Pakistan, were determined by using atomic absorption spectrophotometer. In addition, these textiles finished products were analyzed in triplicate for physical parameters assessment. It was found that the concentration of nickel was beyond the permissible limits in 9 out of 10 samples, chromium in 5 samples, and copper in 2 samples. A further investigation could be carried out to correlate the physicochemical results and heavy metal contents in the textile products.

KEYWORDS: Color fastness, Light fastness, Rubbing organic solvent, Spray rating, Tensile strength, Textile finished products.

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Short Communication

INTRODUCTION

Despite the benefits to the country as one of the contributing sectors in terms of gross domestic product and employment, textile industry has been considered as one of the biggest sources of environmental pollution in Pakistan especially in water pollution. The textile industry is producing harmful and contaminated waste, comprising of 95% and 5% its share from coloring and rinsing processes, respectively (Sirait, 2018). The textile industry is considered is one of the most offender industries due to highest use of hazardous chemicals. Only small quantity of approximately 1% of natural dyes are used by textile sector (Senthil *et al.*, 2015).

Some chemicals such as iron and manganese are deliberately used during the process of bleaching by industry owners to improve the quality and performance of the finished fabric (Yu *et al.*, 2017; Hage *et al.*, 2013). The potential for developing natural dyes to replace synthetic dyes are still open wide, and mordant has become as one of the commonly used dyes by some manufacturers. Mordant is a substance that binds dyes to fabric fiber so it makes the color resistant for washing and sunlight (Indrianingsih & Darsih, 2013). Unfortunately, mordant is not chemically environmentally friendly where it contains heavy metal and has to be used in high concentration for producing stable and good quality of the dyeing process. The use of mordant such as alum and iron are very effective (Teli, *et al.*, 2013), but are very dangerous for human health and the environment (Krizova, 2015). In addition, the cotton crop that is cultivated on approximately 2.5% irrigated land of the world uses huge quantity of different chemicals and called the dirtiest crop because of its association with hazard chemicals during entire crop period, which severely affect the environment and ultimately the natural resources including water, soil, and air (Pan *et al.*, 2008). The crop is getting 25% insecticide used in the world crops (EJF, 2007) which is the highest of chemicals usage

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on a single crop. Some of these chemicals that are found in dyes and stay in the finish product are carcinogenic, considered as free formaldehyde and pentachlorophenol in nature (Ansari, 1999). This paper investigates the heavy metal contents in some finished textile products as well as their physicochemical parameters.

METHODOLOGY

Collection of Samples

Ten samples of finished textile fibers that are mostly used by women of different types including cotton, polyester, nylon, and polypropylene, and of different colors including white, green, brown, orange, pink, purple, red, yellow, grey, and blue, were collected from the different shops of local markets in Hyderabad Pakistan. The samples were collected in triplicate and labeled S-1 to S-10 (ten samples in total).

Analytical Procedure

Heavy metal contains specifically nickel (Ni), chromium (Cr), iron (Fe), copper (Cu) was determined using Atomic Absorption Spectrophotometer model Hitachi Z-5000 Polarized Zeeman Flame. Perspiration test was conducted based on standard ISO-105-EO4 method. 4 cm x 10 cm sample was used and the test was conducted at 37 ^{o}C for 4 hours using Perspirometer SDL ATLAS M-231 and incubator SDL ATLAS G-209 for the analysis. Similar instrumentations and samples conditions were used for color fastness to normal water and to sea water based on ISO/IEC-105-EO1 and ISO-105-EO2, respectively. Weight of fabric as determined based on standard ISO-1833 where samples were cut into pieces using GSM Hans Schmidt & Co. GmbH cutter then weighted using OHAUS Explorer Pro EP2102.

Spray rating test was conducted using MESDAN Lab instrument according to AATCC-22 standard with 18 cm x 18 cm, at temperature 27 ^{o}C for 25 seconds. Rubbing fastness was also conducted as per standard ISO-105-X12 for dry and wet rubbing using Crock meter. In addition, rubbing with organic solvent of perchloro ethylene and alcohol were also conducted as per standard ISO-105-DO2. Tensile strength test was conducted as per guidance of ISO-13934-1 standard using 20 cm x 50 cm sample size, and the fabric thickness was determined based on ISO-5084 standard using Thickness tester. Finally, light fastness parameter was analysed in guidance of standard AS-4.2.1 where 4 cm x 10 cm sample was exposed for 100 hours to light from Mercury blended tungsten lamp (MBTL).

RESULT AND DISCUSSION

Table 1 shows the heavy metal contents of all the textile finished products investigated in this paper. It can be seen that the nickel contents in almost all fabric samples are higher than the permissible limit by OEKOTEX-2021 except S-8. Even though so, it was just 0.2 lower than the upper limit which is 4mg/kg. For iron, although no specific limit is given in OEKOTEX-2021 and most guidelines, the content is considered quite high where 7 out of 10 samples has over 50 mg/kg of concentration.

Half of the samples found to have chromium that exceeded the limit of 2 mg/kg with sample S-5 being the highest which is 7.6 mg/kg. On the other hand, most samples found to have a lower copper content where only two samples were found to have exceeded the limit (50mg/kg) with S-8 to have

highest which is 88.3 mg/kg while the other is just slightly higher than the permissible content which is 52.3 mg/kg.

Table 1. Results of Heavy Metals from textile finished products

S.No	Nickel	Limit	Iron	Limit	Chromium	Limit	Copper	Limit
S-1	**6.50**	**1-4**	37.5	NLD**	**3.5**	**1-2**	5.4	25-50
S-2	**5.90**	**1-4**	28.6	NLD**	0.7	1-2	4.0	25-50
S-3	**5.50**	**1-4**	**58.4**	**NLD****	1.0	1-2	3.5	25-50
S-4	**6.20**	**1-4**	**55.55**	**NLD****	2.0	1-2	**52.3**	**25-50**
S-5	**4.98**	**1-4**	36.4	NLD**	**7.6**	**1-2**	29.3	25-50
S-6	**4.40**	**1-4**	**81.3**	**NLD****	**3.7**	**1-2**	3.7	25-50
S-7	**4.01**	**1-4**	**85.4**	**NLD****	**7.2**	**1-2**	5.0	25-50
S-8	3.80	1-4	**96.4**	**NLD****	**6.9**	**1-2**	**88.3**	**25-50**
S-9	**4.40**	**1-4**	**71.1**	**NLD****	1.0	1-2	6.7	25-50
S-10	**5.00**	**1-4**	**59.4**	**NLD****	0.5	1-2	3.4	25-50

NOTE: All results are measured in mg/kg ** No Limits Define

Table 2 shows the physicochemical test results in this paper. The result, especially for color fastness to water shows the low quality of textile finished products where only two samples (S-8 and S-9) are within the range while all others could not meet the OEKOTEX guidelines. The weight of most fabric samples was fallen as very light except S-3 and S-10, which is generally suitable for summer season in Pakistan.

Table 2. Physicochemical results of textile finished products

Parameters		S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
Color fastness to water		4-5	4-5	4-5	4-5	4-5	4-5	4-5	3	3	4-5
Color fatness to sea water		4-5	4-5	4-5	4-5	4-5	4-5	4-5	3-4	3-4	4-5
Spray rating		50	50	70	50	50	50	50	50	50	50
Crocking	Dry	4.5	4.5	4.5	4.5	4.5	4.5	4.5	3	3-4	4-5
	Wet	5	4.5	4.5	4.5	4.5	4.5	4.5	1-2	2	4-5
Tensile strength (N)	Warp	112	239.4	251.6	120	386	282.1	371	95.0	132	247.6
	Weft	97.3	271.6	164.4	105	194.4	77.8	192.5	170.3	118	312
Weight of fabric		68.56	56.29	328.57	74.64	106.35	66.11	48.95	91.19	68.18	155.2
Fiber thickness (mm)		0.208	0.265	0.826	0.190	0.331	0.321	0.171	0.481	0.232	0.621
Color fastness to rubbing organic solvent		4/5	4/5	4/5	4/5	4	4	4	2	2/3	4
Light fastness		4-5	4.0	4-5	4.0	4-0	4-5	4-5	3-4	3.0	4-5

The presence of heavy metals in textile finished products is due to the process of dying by using different chemicals such as use of vanadium compounds as a catalyst for aniline black dye production (Chakraborty, 2010; Fortoul, 2014). To raise the different colors such as orange and yellow, using different heavy metals such as copper and nickel in dying process as a mordant and chromium-based dyes are quite common (Sekar, 2011; Menezes, 2010; Feiz & Norouzi, 2014). These metals are highly toxic and can accumulate in skin and ultimately absorbed by different parts of body especially liver and kidney. In some cases, the accumulation of these toxic metals may affect the nervus system. This study shows that there is huge amount of heavy metal especially nickel and chromium which may affect the human body.

The heavy metal contents found in this study were similar the finding by Dogan *et al*. (2002) Saracoglu *et al.* (2003) and Tuzen *et al.* (2008). Another study by Gurses *et al.* (2021) indicates the continuously discharge of textile effluent is detected with huge contents of heavy metals which may also affect our environment.

CONCLUSION

Obviously, people enjoy fashion, textile design, and related activities. Unfortunately, consumers buy and use finished textile items that consist of chemicals that are detrimental to human health, and after washing, those products have unavoidable harmful impacts on the environment. Almost all dyes used in current manufacturing process of textile affect human skin and sometimes cause of eyes irritation. In addition, the chemicals used in the textile industry and its products become one of the sources of heavy metal that is harmful to our environment, and when those textile products are wore, they also could affect human body. This study indicate that the quality of textile finished products including cotton, polyester, polypropylene and nylon were low in quality, but most importantly they have huge quantity of heavy metals. The use of chemical with heavy metals in dying process should be minimized or completely stopped, and the related industries are encouraged to use natural dyes, which can be a mean in protecting human from heavy metal contamination as well as water resources.

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