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Original Article

Identification of Washing Process or Chemical Concentration Impacted on the Environment most which use in Washing Factory and Find out Eco Friendly Sustainable Solutions as a Green Chemistry Alternative

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Abstract *- Denim washing is gradually entering the list of vital procedures of fulfilling the needs of the world's evolving fashion industry. The objective of this research is to provide a extensive overview of enzyme wash, bleach wash, acid wash for garments and find out which wash or chemical concentration affected the environment most and compare with eco-friendly sustainable process. The research paper are written for the garments washing professional for detailed casing information.*

In this research use indigo dyed denim garments and five parameter of commercial enzyme (1 g/l, 1.5 g/l, 2 g/l, 2.5 g/l and 3 g/l) for enzyme wash, five parameters of Calcium hypochlorite (1 g/l, 1.5 g/l, 2 g/l, 2.5 g/l and 3 g/l) for bleach wash and five parameters of Potassium permanganate (2 g/l, 5 g/l, 10 g/l, 15 g/l and 20 g/l) for acid wash. Similarly use five parameters of eco-friendly chemical for enzyme wash, bleach wash and acid wash.

After Enzyme wash, Bleach wash and Acid wash we do every sample environmental impact measurement (EIM) test by jeanologia. The research test result shows high for enzyme wash, Bleach wash and Acid wash when we use regular chemical but in case of green chemical EIM result show low impact. Green chemical concentration give better performance and also these chemical impacted the environment 80% less than regular used chemical. When chemical concentration increased also impacted the environment more. But in case of green chemical increment of green chemical concentration didn't affect the environment. But for three most popular wash enzyme wash, Bleach wash and Acid wash when used regular chemical Acid washed chemical impacted the environment most, 2ndly Bleach Wash and 3rdly Enzyme wash. But when do Ozone it's reduce enzyme wash time, chemical concentration and also created effect like bleach wash. Ozone is eco-friendly process and EIM test result shows zero.That's why when do enzyme wash, Bleach wash and Acid wash we use Ozone and green chemical instead of commercial enzyme, Sodium hypochlorite (NaClO) and Potassium permanganate (KMnO4).

Keywords - *Sustainable Garments Washing, Sustainable Denim washing, Eco-Friendly Denim Wash, Green Chemical, Environmental impact measurement.*

I. INTRODUCTION

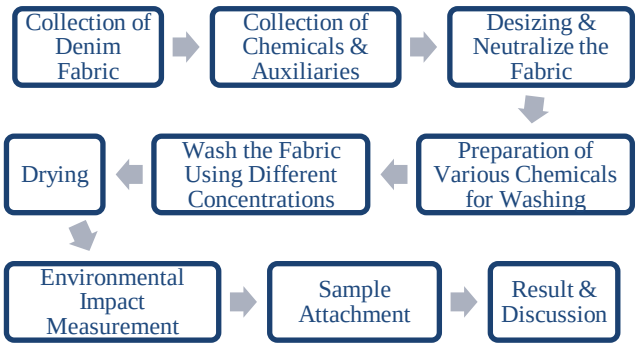
Denim washing is increasingly being added to the indispensable process of meeting the needs of the world's ever-changing fashion industry [1]. Industrial Garments Washing is one of the major important parts for Textile sector. By industrial garments washing, we can remove dust, dirt and infections material. For improving special look on garments as per fashion requirement [2].The main step in the garment finishing process in washing, Enzyme Wash, Bleach Wash, Acid Wash these type of finishing treatment that is used to make stitched clothes more appealing, stylish, Fashionable, soft, and comfy while also increasing value[3].

Furthermore, manufacturers and customers in the modern world are trending upward in their perceptions of sustainability. However, washing denim is considered to have a direct impact on the environment, as chemicals and many other pollutants are released in the process that affect the water supply. In this process, the denim industry has faced challenges at all levels. Therefore, it is necessary to study the sustainability issues related to the washing of denim [4].Environmental Sustainability Such concepts as zero-waste thinking, recycling, green-living, eco-friendly

production and lifestyle etc. are growing more and more popular, gathering nature loving activists all over the world, since Climate Change is considered to be the most urgent global concern of the future of humanity. Sustainability refers to the protection of scarce and important natural resources for future generations. In most manufacturing industries, sustainability is the main motivation. Sustainability practices explain the participation of clients and companies outside the world, while the environment and the community are of utmost importance [5].

However, when choosing denim clothing, customers are influenced by factors such as fashion, attractiveness and aesthetics. Denim clothing, in the primary process, does not inherit the properties desired by the customer. However, it becomes effective after washing due to its new durability, comfort, softness, appearance and low cost, resulting in complete customer satisfaction [6].The final stage of denim production is washing, which is considered an essential component of finished denim. However, numerous denim-washing procedures are used to create the fading effect, softness, and relaxed feeling of denim [7, 8]. Industrial processes are associated with different environmental impacts, which mainly revolve around the heavy use of chemicals and the high use of energy and water resources, efficient wastewater treatment, etc. Jeans or denim are also considered the most polluting textiles in the world, as a result of the indigo dyeing process, the amount of water required to clean it, as well as the chemicals used [9]. In terms of achieving sustainability in the denim industry, uses of advanced materials, green chemical and the latest technology and environment friendly washing techniques are establishing the sustainable production of denim [10]. The objective of this this research find out which washing process and chemical polluted environment most and measurement the every washing process or chemicals environment impacted score and find out eco-friendly solution.

A. Outline of the project work is given below:



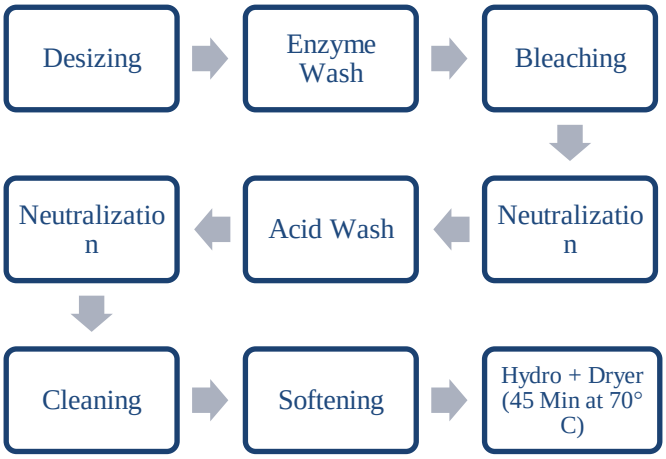
II. MATERIALS AND METHODS

99% Cotton & 1% Spandex indigo dyed denim apparel was used for this experiment. The fabric 3/1 warp-faced twill design respectively and weight 10.62 OZ or GSM 360.

A. Chemicals use in this research work:

SI NO	Process	Used Chemical	Low Impacted or Green Chemical for Wash
1	Enzyme	Commercial Enzyme	Endoglucanase-rich neutral Enzyme,Nova Stone NEBU (Sustainable enzyme)
2	Bleach	Sodium Hypochlorite (NaOCl)	avol fade
3	Neutral	Sodium Metabisulphite (Na2S2O5)	Lava Con Mex
4	Acid Wash/PP spray	Potassium Permanganate (KMnO4)	PP Replacement chemical name ► Remover IND/J ►Catalyst IND/J
5	Neutral	Sodium Metabisulphite (Na2S2O5)	Lava Con Mex
6	Clean Up	Protector LY	Protector KCL
7	Ozone	O3 gas	

B. Flow Chart of Washing



Recipe For sample 01
Desizing:
Soda Ash(Na2CO3)-2g/l
Anti Back Staining- 1g/l
Time: 10 Min
Tem: 50° C
M:L : 1:08

Enzyme Wash:
Commercial Enzyme -1 g/l
New Stone-2 kg
Anti-Back Staining- 1g/l
Time: 30 Min
Tem: 40° C
M:L : 1:08

Bleaching:
Sodium Hypochlorite (NaOCl)-1g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Acid Wash:
Potassium permanganate (KMnO4)-2g/l
Lava Cone PAP- 1g/l
Sponge ball- 200 pcs
Water: 1 ltr
Time: 5 Min
Tem: RT
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite- 2g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Cleaning:
Hydrogen peroxide -2g/l
Cross color Miro- 1g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Softening:
Wetsoft -700 - 2g/l
Acetic Acid -0.5 g/l
Time: 5 Min
Tem: RT
M:L : 1:08
Hydro + Dryer (45 Min at 70° C)

Recipe For sample 02
Desizing:
Soda Ash(Na2CO3)-2g/l
Anti Back Staining- 1g/l
Time: 10 Min
Tem: 50° C
M:L : 1:08

Enzyme Wash:
Commercial Enzyme -1.5 g/l
New Stone-2 kg
Anti-Back Staining- 1 g/l
Time: 30 Min
Tem: 40° C
M:L : 1:08

Bleaching:
Sodium Hypochlorite (NaOCl)-1.5 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Acid Wash:
Potassium permanganate (KMnO4)-5 g/l
Lava Cone PAP- 2.5 g/l
Sponge ball- 200 pcs
Water: 1 ltr
Time: 5 Min
Tem: RT
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Cleaning:
Hydrogen peroxide -2g/l
Crosscolor Miro- 1g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Softening:
Wetsoft -700 - 2g/l
Acetic Acid -0.5 g/l

Time: 5 Min
Tem: RT
M:L : 1:08
Hydro + Dryer (45 Min at 70° C)

Recipe For sample 03
Desizing:
Soda Ash (Na2CO3)-2g/l
Anti-Back Staining- 1g/l
Time: 10 Min
Tem: 50° C
M:L : 1:08

Enzyme Wash:
Commercial Enzyme -2 g/l
New Stone-2 kg
Anti-Back Staining- 1 g/l
Time: 30 Min
Tem: 40° C
M:L : 1:08

Bleaching:
Sodium Hypochlorite (NaOCl)-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Acid Wash:
Potassium permanganate (KMnO4)-10 g/l
Lava Cone PAP- 5g/l
Sponge ball- 200 pcs
Water: 1 ltr
Time: 5 Min
Tem: RT
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Cleaning:
Hydrogen peroxide -2g/l
Crosscolor Miro- 1g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Softening:
Wetsoft -700 - 2g/l
Acetic Acid -0.5 g/l
Time: 5 Min
Tem: RT
M:L : 1:08
Hydro + Dryer (45 Min at 70° C)

Recipe For sample 04

Desizing:
Soda Ash (Na2CO3)-2 g/l
Anti-Back Staining- 1g/l
Time: 10 Min
Tem: 50° C
M:L : 1:08

Enzyme Wash:
Commercial Enzyme -2.5 g/l
New Stone-2 kg
Anti-Back Staining- 1 g/l
Time: 30 Min
Tem: 40° C
M:L : 1:08

Bleaching:
Sodium Hypochlorite (NaOCl)-2.5 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Acid Wash:
Potassium permanganate (KMnO4)-15 g/l
Lava Cone PAP- 7.5 g/l
Sponge ball- 200 pcs
Water: 1 ltr
Time: 5 Min
Tem: RT
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Cleaning:
Hydrogen peroxide -2g/l
Crosscolor Miro- 1g/l
Time: 5 Min
Tem: 40° C

M:L : 1:08

Softening:
Wetsoft -700 - 2g/l
Acetic Acid -0.5 g/l
Time: 5 Min
Tem: RT
M:L : 1:08
Hydro + Dryer (45 Min at 70° C)

Recipe For sample 05
Desizing:
Soda Ash (Na2CO3)-2g/l
Anti-Back Staining- 1g/l
Time: 10 Min
Tem: 50° C
M:L : 1:08

Enzyme Wash:
Commercial Enzyme -3 g/l
New Stone-2 kg
Anti-Back Staining- 1 g/l
Time: 30 Min
Tem: 40° C
M:L : 1:08

Bleaching:
Sodium Hypochlorite (NaOCl)-3 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Acid Wash:
Potassium permanganate (KMnO4)-20 g/l
Lava Cone PAP- 10g/l
Sponge ball- 200 pcs
Water: 1 ltr
Time: 5 Min
Tem: RT
M:L : 1:08

Neutralization:
Sodium Meta Bisulphaite-2 g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Cleaning:
Hydrogen peroxide -2g/l
Crosscolor Miro- 1g/l
Time: 5 Min
Tem: 40° C
M:L : 1:08

Softening:
Wetsoft -700 - 2g/l
Acetic Acid -0.5 g/l
Time: 5 Min
Tem: RT
M:L : 1:08
Hydro + Dryer (45 Min at 70°)

III. RESULTS AND DISCUSSION

Table 01: After Enzyme wash the effect variation obtained stated below

Sample No:	Enzyme (g/l)	Sample Representation
01	1	
02	1.5	
03	2	

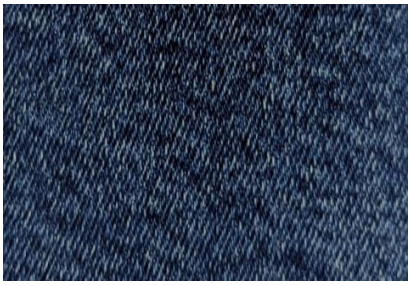
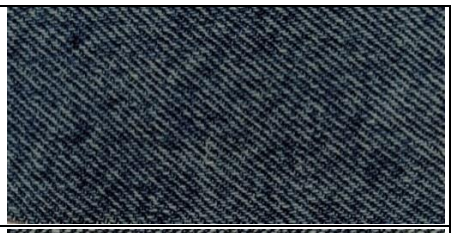
04	2.5	
05	3	

Table 02: After Bleach wash the effect variation obtained stated below

Sl. No:	Bleach (g/l)	Sample Representation
01	1	
02	1.5	
03	2	
04	2.5	
05	3	

Table 03: After Acid wash the effect variation obtained stated below

Sl. No:	KMnO4 (g/l)	Sample Representation
01	2	
02	5	
03	10	

04	15	
05	20	

Table 04: EIM (Environmental Impact Measurement) Test result for Enzyme Wash:

Sample No	Water effective (l/garment)		Energy effective (kWh/garment)		Chemical Impact (garment)		Worker Impact (garment)		EIM Score	
	Regular used Chemical	Green C hemical	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical
01	4.80	2.40	0.16	0.14	12	1	7	2	9	2
02	4.80	2.40	0.16	0.14	12	1	7	2	9	2
03	4.80	2.40	0.16	0.14	12.5	1	7	2	9	2
04	7.20	3	0.24	0.17	13	1	7	2	10	3
05	7.20	3.40	0.24	0.21	13	1	7	2	10	3

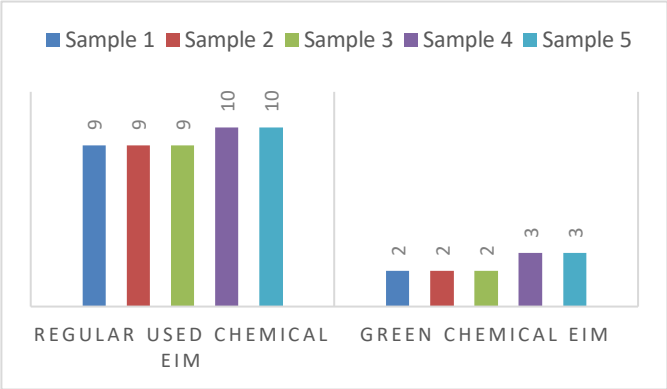


Figure 01: Comparison between Regular used Chemical EIM & Green Chemical EIM report (Enzyme Wash)

According this figure sample 4 and 5 impacted the environment most. But when use green chemical this EIM is lower than the regular used chemical. That's why during enzyme washing time we always use green chemical or which chemical is sustainable or eco-friendly don't use these chemical which are affected the environment.

Table 05: EIM (Environmental Impact Measurement) Test result for Bleach Wash

Sample No	Water effective (l/garment)		Energy effective (kWh/garment)		Chemical Impact (garment)		Worker Impact (garment)		EIM Score	
	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical	Regular used Chemical	Green Chemical
01	8	2.4	0.17	0.05	20	3.5	15	1	15	2
02	8	2.4	0.17	0.05	20	3.5	15	1	15	2
03	8	3	0.17	0.07	20	3.5	15	1	15	3
04	10	3.5	0.22	0.08	20	3.5	15	1	16	3
05	12	3.6	0.26	0.08	20	3.5	15	1	17	3

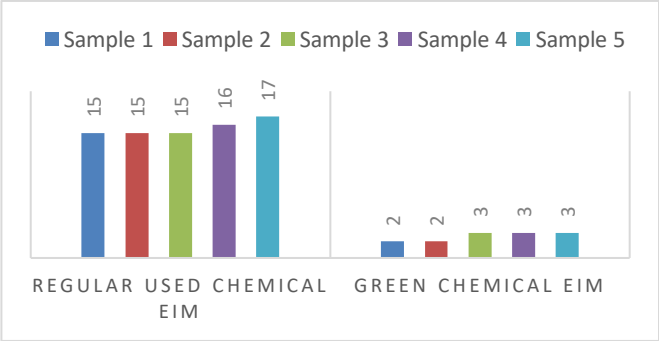


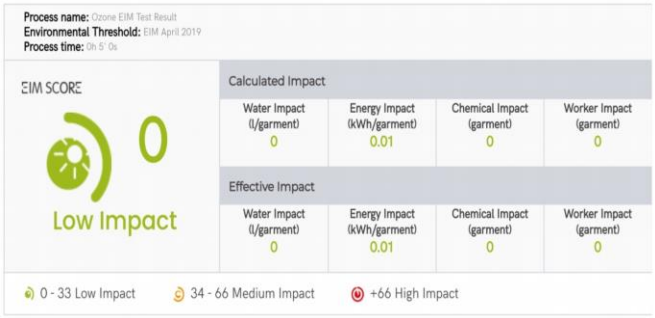
Figure 02: Comparison between Regular used Chemical EIM & Green Chemical EIM report (Bleach Wash)

Above this figure shows when use Sodium Hypochlorite (NaOCl) for bleach wash environmental impact measurement (EIM) shows high. Increment of chemical concentration EIM also increase. Sodium Hypochlorite (NaOCl) is a high harmful chemical for environment but day by day we use it in washing factory. But for bleach wash when use green chemical EIM result shows low and its environment friendly also worker friendly. Now a days low impacted eco-friendly commercial bleaching agent available in market. For our environment we avoid this harmful chemical and use eco-friendly and worker friendly bleaching agent.

A. After Ozone the effect variation obtained stated below:

Ozone is a eco-friendly chemical, It's save chemical, time and wash cycle and changing shade without any wet-process, clean the surface of tinted surface, remove back stain and create same effect as bleaching wash. Above this figure shows different among before ozone shade, after ozone shade and after ozone normal wash shade. When we do ozone this increase the surface effect and yellowish the sample. Then normal wash this ozone sample got more effect on fabric surface and its lighter this sample shade like bleach wash. If we use ozone before enzyme wash it's reduce enzyme washing time save energy, water and chemical.

Ozone EIM (Environmental Impact Measurement) Test result:



Above this report shows after five minute enzyme wash EIM (Environmental Impact Measurement) is zero. So we need to increase using ozone in washing section more. According to EIM report ozone process save water, Energy and chemical and in short time we get desired result by Ozone. Ozone process save enzyme wash time and reduce wet bleaching. For eco-friendly sustainable wash Ozone process more important for washing sector.

Table 06: EIM (Environmental Impact Measurement) Test result for Acid Wash

Sample No	Water effective (l/garment)		Energy effective (kWh/garment)		Chemical Impact (garment)		Worker Impact (garment)		EIM Score	
	Regular used Chemical	In case of Green Chemical	Regular used Chemical	In case of Green Chemical	Regular used Chemical	In case of Green Chemical	Regular used Chemical	In case of Green Chemical	Regular used Chemical	In case of Green Chemical
01	5	3	0.2	0.02	35	6	27.5	7	25	6
02	5	3	0.2	0.02	35	6	27.5	7	25	6
03	6.25	3	0.2	0.02	35	6	27.5	7	25	6
04	7.5	3.5	0.3	0.03	35	6	27.5	7	26	7
05	7.5	3.5	0.3	0.03	35	6	27.5	7	26	7

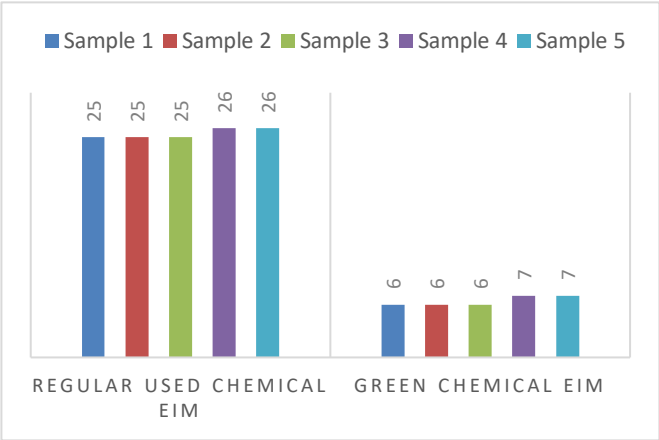


Figure 03: Comparison between Regular used Chemical EIM & Green Chemical EIM report (Acid Wash)

Above this figure shows when use Potassium permanganate ($KMnO_4$) for Acid Wash environmental impact measurement report shows high. According to EIM report increment chemical concentration EIM also increase. Potassium permanganate ($KMnO_4$) is a high harmful chemical for environment and for worker but day by day we use it in washing factory. But for Acid wash when use green chemical (PP Replacement chemical like Remover IND/J

&Catalyst IND/J) its not impacted the environment and also worker friendly. For our environment we avoid this harmful chemical and use eco-friendly and worker friendly PP Replacement chemical.

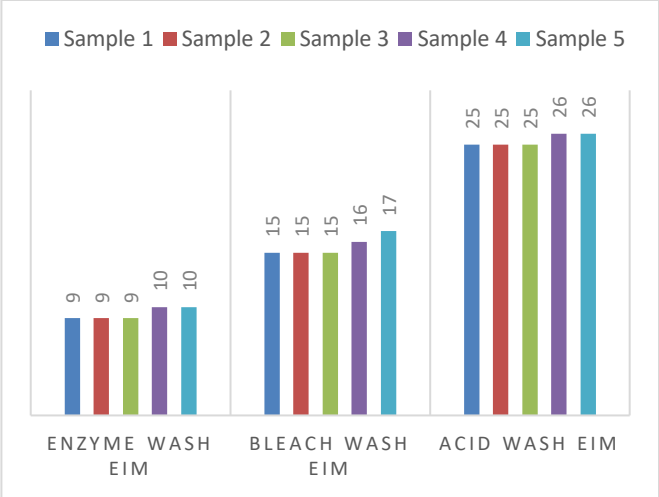


Figure 04: Comparison among Enzyme Wash, Bleach Wash and Acid Wash EIM Report

Above this figure shows during enzyme wash we use regular chemical this time EIM report high because our regular used chemical impacted the environment most. Similarly for Bleach wash and acid wash EIM shows high. Environmental report shows for three most popular wash like enzyme wash, Bleach wash and Acid wash when used regular chemical Acid wash chemical Potassium permanganate ($KMnO_4$) concentration impacted the environment most, 2ndly Bleach Wash chemical Sodium hypochlorite (NaClO) and 3rdly Enzyme wash. But when we use green chemical for three wash EIM show low score. In other word in case of green chemical these impacted the environment 80% less than regular used chemical. But we regularly use these harmful chemical in our industry.

IV. CONCLUSIONS

Washing gave different look to the garments. Garments washing are mainly done after stitching wash types actually depends on the product matures and usages used on consumer demand and fashion trend buyer will fix the washing type of any product. For example stone enzyme wash is required for denim item but light softener wash is perfect for knitted item.

According to visual effect this research paper shows for enzyme wash, Bleach Wash and Acid Wash sample number five is better and more attractive than other sample. But increment of chemical concentration also increase EIM score like enzyme wash sample no 4&5 impacted the environment most. For Bleach wash sample no 5 shows EIM score high. Similarly for acid wash sample no 5 impacted environment most but aesthetic look more attractive than other four sample. But comparison result shows Acid wash chemical Potassium permanganate ($KMnO_4$) concentration impacted the environment most, 2ndly Bleach Wash chemical Sodium hypochlorite (NaClO) and 3rdly Enzyme wash.

In Case of green chemical, enzyme wash, Bleach wash and acid wash chemical concentration shows low EIM result less than 80% than regular used chemical. We find out alternative way like Ozone process reduce desizing process and enzyme wash time, chemical concentration. Its create effect like bleach wash. When we need bleach wash effect after short time enzyme we will do ozone instead of bleach wash.

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