Comparative studies on fastness property of different dye colours on different fabrics

Science Fair Project Report

Level : Middle Level

Category : Physical Science

Submitted by

Aseem Khan R

(Grade 6)

ARRAHMAAN
INTERNATIONAL SCHOOL

(Creating the community of Excellence)

Comparative studies on fastness property of different dye colours on different fabrics

CONTENTS

Comparative studies on fastness property of different dye colours on different fabrics

ABSTRACT

Colour has become our life's commodity. Choosing a rare shade - be it for painting homes, spraying cars or for wearing clothes, has now become a means of luxury. Besides pleasing, the choice of selection should be appropriate keeping in mind its durability. Colour fading is an unavoidable phenomenon, in colorimetry, the knowledge of which is essential in deciding which colour is to be applied where for better fastness. Colour fastness is the resistance of a dyed fabric to fading.

This project aims to experiment and visualize the fastness property on comparative basis of three different dye colours namely, Red, Green and Yellow on fabrics. The colour fastness is tested for exposure to light, soap washing and wet rubbing. The assessment of the colour intensity is limited to small scale by adopting the method of comparative visual assessment of actual and exposed fabrics instead of using Grey Scale. The fabrics to be tested were prepared through dyeing of four cross combination of two different sources (Natural and Synthetic) of dye with that of fabrics. Natural dyes for Red, Green and Yellow were extracted from Ruby Red Button Rose, Marikozhundu and Marigold flower respectively.

INTRODUCTION (BACKGROUND INFORMATION)

Role of Colours

Colours are present all around us and are involved in every aspect of our life, starting from the "treasured" crayon boxes in kindergarten to the latest clothes in fashion this season. They have more influence on us than we can possibly imagine. Life would have been dull and meaningless without colours for our choice of decoration and clothing depends on colours.

Imagine a world without colour. Everything would be in monochrome. The feeling would be equivalent to living in a black and white television. Colours make nature, fashion, flags and the various races much more interesting and diverse. Thus colours have become vital for our lifestyle. However precious it can be, it should be a digestible truth that all colours will be susceptible to considerable fading over a period of time, but just our eyes can't catch with.

Chemical formulation of Dyes

Dyes are coloured substances characterized by the presence of delocalized aromatic rings, Chromophores and colour intensifying agents Auxochromes.

Classification of dyes

Dyes can be classified based on various criteria. Based on the source of dye, it may be Natural and Synthetic. The majority of natural dyes are derived from plant sources: roots, berries, bark, leaves, and wood, fungi, and lichens. Most dyes are synthetic and made from petrochemicals.

Colour Perception in Human Eye

Colours are vibration of lights. The human eye is the mean that is used to detect colour. The 'colour' of an object is the ***wavelengths of light that it reflects***. This is determined by the arrangement of electrons in the atoms of that substance that will absorb and re-emit photons of particular energies according to quantum laws. So tomatoes are red because the pigment atoms in the skin absorb photons of all energies except those that correspond to red wavelengths of light, which they reflect back to our eye. But the colour that we perceive is about much more than the wavelengths of light. The visual cortex of your brain has evolved to perform lots of context-dependent corrections to correct for the colour and intensity of the ambient light. The effect is that the colour of an object has just as much to do with the colour you think it 'should' be.

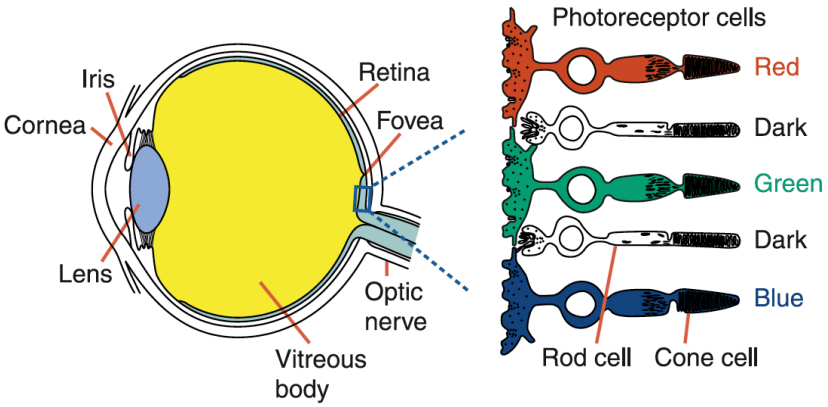


Figure 1: Colour perception in Human Eye

Colour Fastness

The way a light is perceived by human is called the colour and this is one of the most important factors in the textile industry. The colour that catches the attention of buyer, its retention capacity, transference, fastness, etc. is some common parameters that are assessed to determine the quality of the fabric. The ability of the fabric to maintain primary color is one of the most important properties of textiles.

The tendency of the garment to retain its colour despite exposing it to harsh conditions can be defined as colour fastness. Colour fastness refers to the resistance of color to fade or bleed of a dyed or printed textile materials to various types of influences e.g. water, light,

rubbing, washing, perspiration etc. It is an important indicator to measure the quality of dyeing products.

Factors Affecting the Color Fastness Properties

The chemical nature of the fibre:

Certain fabrics like polyester, viscose, cellulose fibre and vat dye have good resistance against external factors and thus have good colour fastness. Some fabrics are produced after mixing different yarns together with synthetic fibre, they have good colour retention capacity with substantive dye.

Cellulosic fibres dyed with reactive or vat dyes will show good fastness properties. Protein fibres dyed with acid mordant and reactive dyes will achieve good fastness properties and so on. That is to say *compatibility of dye with the fibre is very important.*

Finishing:

Sometimes, to improve the usability of the fabric, the natural texture of the fabric is altered by changing the finishing used. In this case, the colour retention of the fabric increased. In practical usage, the finishing is altered deliberately to improve the color fastness of the fabric.

Colour:

The fastness depends a lot on the tone of the colour. E.g. Jet black has less colour fastness property whereas colours like lime, soft pink, etc. have very strong fastness.

The molecular structure of a dye molecule:

The dye with bigger molecules is easy to fix on the fibre. Also, there are many insoluble dyes available to increase the colour fastness when the fabric is washed. In what way, the dye is fixed on the fabric impacts the colour fastness property.

Chemistry of colour fading

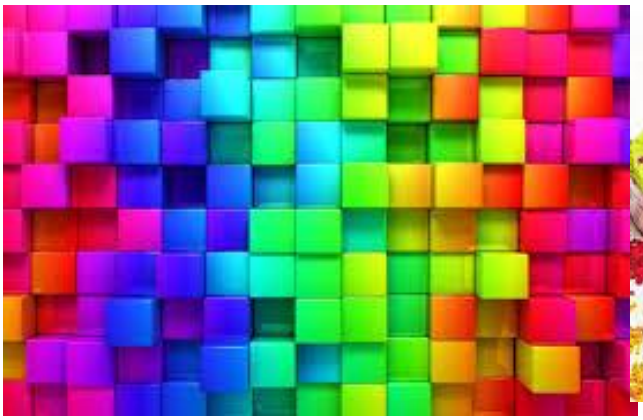
Dyes are *usually* organic or organo-metallic compounds with many resonant double (possibly triple) bonds. These molecules are big enough to interact with Electro Magnetic waves. However, they are also very stable because they contain so many resonant bonds that they can absorb different wavelengths of light without breaking apart instantaneously.

STATEMENT OF THE PROBLEM

Retention of colour takes more effort and energy than producing it. It is as simple as 'Destruction is more prone to occur than Construction'. Colour Fastness is an important aspect which determines the quality of the dyed product, and can contribute to the success or failure of a firm. Knowing the property can help in selecting the appropriate colour for the selected application so as to avoid the maximum loss. Colour fastness depends on various factors and some of them yet to sprout in this world. Here, influence of colour alone taken into consideration for testing the fastness while limiting others.

HYPOTHESIS

Red synthetic dye applied in mixed polyester is more colour fast (resistant to fading) than others.



DESIGN OF STUDY

Experiment 1:	*Experiment 2:*
INDEPENDENT VARIABLE: • Colour and Nature of the dye (Red, Yellow, Green– Natural, Red, Yellow, Green – Synthetic) *DEPENDENT VARIABLE:* • Property of Colour fastness (resistance to fading) *CONTROLLED VARIABLES:* • *Nature of the fabric (Natural)* • Dimensions of fabric • Quantity of dye used • Measurement aid used for testing fading (scale) • Dyeing conditions • Exposure testing conditions (such aslight, heat, wet rubbing, soap wash)	*INDEPENDENT VARIABLE:* • Colour and Nature of the dye (Red, Yellow, Green – Natural, Red, Yellow, Green – Synthetic) *DEPENDENT VARIABLE:* • Property of Colour fastness (resistance to fading) *CONTROLLED VARIABLES:* • *Nature of the fabric (Synthetic)* • Dimensions of fabric • Quantity of dye used • Measurement aid used for testing fading (scale) • Dyeing conditions • Exposure testing conditions (such as light, heat, wet rubbing, soap wash)

MATERIALS:

- Powdered dyes of colour red, yellow, green (synthetic)
- Natural dyes to be extracted from

  Trail 1

  Beetroot– *Beta vulgaris* (Red)

  Chrysanthemum - *Chrysanthemum indicum*(Yellow)

  Lavender – *Artenuisia vulgaris* (Green)

  Trail 2

  Ruby Button Rose (Red)
- Cotton (Natural fabric) and mixed polyester (synthetic fabric) each of length 1 m

- Colour scale (Red, Yellow, Green)
- pH meter and pH paper
- De-ionized water
- Induction stove
- Glass rod for stirring
- Measuring cylinder 100ml
- Stainless steel vessel
- Glass tumblers
- Beakers 500ml, 250ml
- Knife
- Scissors
- Water (warm/cold)
- Vinegar
- Detergent powder
- Piece of cloth for rubbing (dried tissue wipes)
- Bowls for washing
- Trays to hold rubbing surface
- Weighing machine
- Strainer
- Plastic tub for washing
- A stand for drying
- Labels

PROCEDURE:

Split the experiment as 1 and 2 based on the nature of the fabric. Set the following four mixed combinations for each colour using the parameters- natural fabric, synthetic fabric, natural dye and synthetic dye:

For Experiment 1

- Natural fabric and a natural dye
- Natural fabric and a synthetic dye

For Experiment 2

- Synthetic fabric and a natural dye
- Synthetic fabric and a synthetic dye

PART 1 - PREPARING THE TEST SAMPLES BY DYEING

STEP 1 (Preparing the fabric)

- Before starting, decide the dimensions of fabric.
- Since it is small scale, keep the fabric dimension sufficient enough for the project.
- Mark and cut out 6 samples of dimension of 25cmx20cm from each of the fabric.
- Prepare the colour fixative bath by mixing 1 part of vinegar to 4 parts of water (50ml in 200 ml of water) in beakers and dip all clothes to be dyed.
- Allow the fabrics to absorb the colour fixative mix for an hour or two.
- Remove the fabrics from the fixative and squeeze it out thoroughly.
- Simultaneously prepare the natural and synthetic dyes.

STEP 2 (Preparation of natural dyes)

- Collect the sufficient quantity of the materials from which dyes to be extracted.
- The plant material should be as fresh as possible.
- Chop the material into small pieces to get more surface area
- Weigh the quantity to 80g each.
- Put it in 3 stainless steel vessel kept on induction stove.
- Add 200-300 ml of water based on the need.
- Allow the mixture to boil and then simmer it,stirring occasionallyusing glass rod for at least an hour until desired colour is obtained.
- Strain out the plant material and return the dye liquid to separate beakers.
- Note down the quantity of the extracted dye.
- Check their pH level using pH meter.

STEP 3 (Preparation of synthetic dyes)

- Dissolve 5g of each of the dye powder separately in 200ml of hot water.

STEP 4 (Dyeing)

- Set the combinations as planned before and label the 12 glass tumblers as follows:

Red N - Cotton	Yellow N - Cotton	Green N - Cotton
Red S - Cotton	Yellow S - Cotton	Green S - Cotton
Red N - Polyester	Yellow N - Polyester	Green N - Polyester
Red S - Polyester	Yellow S - Polyester	Green S - Polyester

(N for natural dye ; S for synthetic dye)

- Transfer 50 ml of each of the prepared dyes to the respective tumblers.
- Place the pre-treated fabrics in the respective dye liquor.
- Carefully keep thetumblers in the water-bath and bring to a slow boil.
- Simmer for an hour, stirring once in a while.
- Turn off the heat after an hour and allow the fabric to sit overnight in the dyebath.
- Next day, manually check the exhaustion by keeping a drop of the dye liquor on the thumb and predicting the exhaustion with the intensity of the dye colour.
- It is advisable to decide the next step based on the observation. When the desired colour is obtained, squeeze the dyed fabric thoroughly and subsequently wash with cold water until colour bleeding stops and water appears clear.
- Air dry at room temperature by hanging them in the hand-made cloth line.
- Let them dry for a day under a shady place.
- Now the fabrics for testing are ready for use.

PART II - TESTING THE FABRICS FOR COLOUR FASTNESS

- Before proceeding, compare the colour of the dyed fabrics with the standard colour scale (prepared for our need) of respective colours and note down the grade accordingly.
- Cut each dyed samples into four equal parts, from which one piece is kept as standard; all the other pieces for testing.
- Expose the dyed fabrics to various conditions such as prolonged light & heat, soap-water wash, wet rubbing in a controlled manner.

Colour fastness to light & heat

- Select an appropriate place which receives maximum sunlight and heat (school terrace)

- Place one set of testing fabrics in that place, 6 hours per day continuously for 10days.
- Check and compare the colour with the colour scale at the end of the day.

Colour fastness to soap wash

- Take 3 bowls for each colour.
- Mix 3g of soap powder in 500ml of water.
- Wash the second set of test fabrics one by onein the soap water until it stops bleeding.
- Rinse it with cold water and drain the excess water by squeezing.
- Dry at room temperature.
- Check the colour with the standard scale.

Colour fastness to wet rubbing

- Take a dried white tissue wipe and cut 12 pieces of dimensions 6cmx3cm.
- Fold it two times and wet it.
- Squeeze the excess water and rub it 25 times on the third set of samples one by one at the constant speed.
- Compare the colour grade with the standard scale**.**

Finally tabulate the observations and compare the results to find which dye colour is fast in which type of fabric under which conditions.

COLLECTION OF DATA- PHOTOGRAPHS


pH checking and transferring fabrics from fixative bath

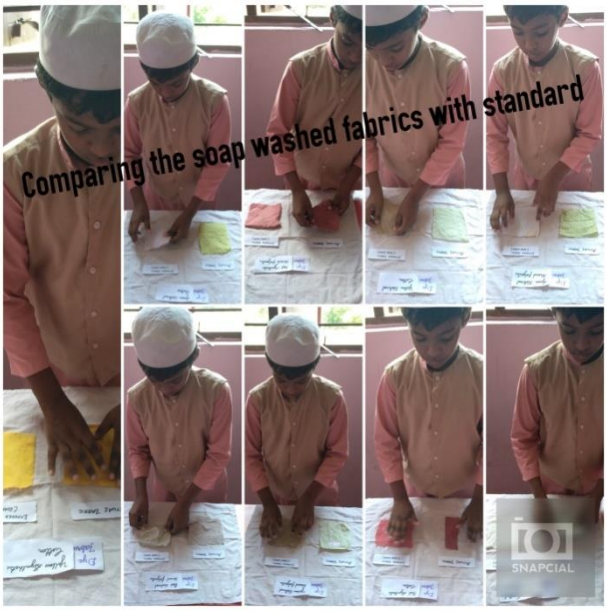

Water bath for dyeing Natural dyes


Dyeing with Natural dyes


Checking the light Fastness on Day 2

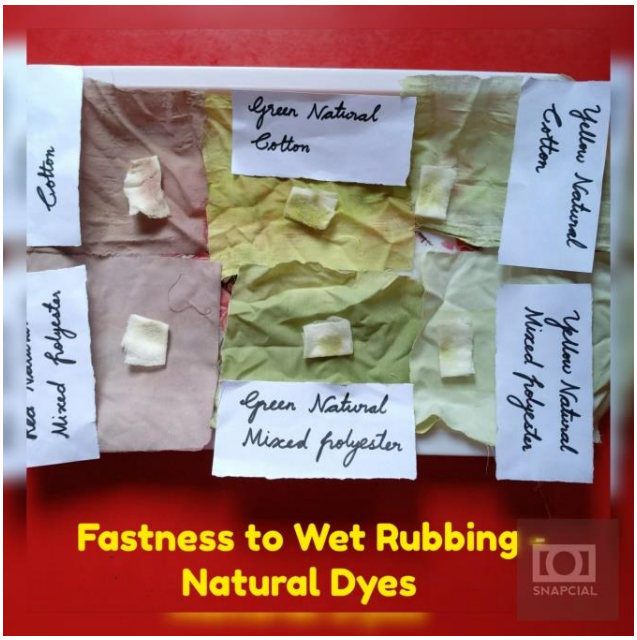

GREEN
YELLOW
RED
Water after soap washing synthe
GREEN
YELLOW
SNAPCIAL


Color Bleeding during Soap washing
SNAPCIAL


Comparing the soap washed fabrics with standard
SNAPCIAL


GREEN
YELLOW
RED
Water after soap washing synthetic dyed fabrics
GREEN
YELLOW
SNAPCIAL


Green Synthetic Cotton
Green Synthetic Mixed polyester
Fastness to Wet Rubbing - Synthetic Dyes


Green Natural Cotton
Green Natural Mixed polyester
Yellow Natural Cotton
Yellow Natural Mixed polyester
Fastness to Wet Rubbing - Natural Dyes


Fastness to soap wash -Red


Fastness to soap wash - Yellow

Fastness to soap wash- Green

Fastness to Wet Rubbing

Wet Rubbing - Red

Fastness to Light - Red


DAY-2
Dye Fabric Yellow Natural Cotton
Actual Fabric
Exposed Fabric (Sunlight)
DAY-2
Dye Fabric Yellow Synthetic Cotton
Actual Fabric
Exposed Fabric (Sunlight)
Fastness to Light - Yellow
DAY-2
Dye Fabric Yellow Natural Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
DAY-2
Dye Fabric Yellow Synthetic Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
SNAPCIAL


DAY-2
Dye Fabric Green Natural Cotton
Actual Fabric
Exposed Fabric (Sunlight)
DAY-2
Dye Fabric Green Synthetic Cotton
Actual Fabric
Exposed Fabric (Sunlight)
Fastness to Light - Green
DAY-2
Dye Fabric Green Natural Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
DAY-2
Dye Fabric Green Synthetic Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
SNAPCIAL


Dye Fabric Red National Cotton
Actual Fabric
Exposed Fabric (Sunlight)
Dye Fabric Red Synthetic Cotton
Actual Fabric
Exposed Fabric (Sunlight)
DAY 3
Dye Fabric Red National Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
Dye Fabric Red Synthetic Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
Fastness to Light - R
SNAPCIAL


Dye Fabric Yellow Natural Cotton
Actual Fabric
Exposed Fabric (Sunlight)
Dye Fabric Yellow Synthetic Cotton
Actual Fabric
Exposed Fabric (Sunlight)
DAY 3
Dye Fabric Green Natural Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
Dye Fabric Yellow Synthetic Mixed polyester
Actual Fabric
Exposed Fabric (Sunlight)
Fastness to Light - Yell
SNAPCIAL


DAY 3
Fastness to Light - G


DAY 6
Fastness to Light - Red


DAY 6
Fastness to Light - Yellow


DAY 6
Fastness to Light - Green


Fastness to Soap Wash - Natural Dyes
Red Cotton
Green cotton
Yellow Cotton
Red Polyester
Green Polyester
Yellow Polyester


Fastness to SoapWash Synthetic Dyes
Red Cotton
Yellow Cotton
Green Cotton
Red Polyester
Yellow Polyester
Green Polyester

Tabulation

Preparation of natural dyes

S. No	***Colour***	***Plant Material used***	***pH of the dye liquor***	***Colour of the liquid***
1.	Red	Beetroot *(Beta vulgaris)*	2	Beetroot Red
		Button rose	2.5	Ruby red
2.	Yellow	Chrysanthemum (*Chrysanthemum indicum)*	5	Lime yellow
3.	Green	Lavender *(Artenuisia vulgaris)*	5	Herbal green

Dyeing

S. No	***Nature of the dye***	***Nature of the fabric***	***Colour of the dye***	***Colour of the dyed fabric***
1.	Natural extract	Cotton	Red	Pale Ruby Red
			Yellow	Lime Yellow
			Green	ChartreuseGreen
		Mixed Polyester	Red	Pale Ruby Red
			Yellow	Pale Yellow
			Green	ChartreuseGreen
2.	Synthetic	Cotton	Red	Crimson Red
			Yellow	Dark Golden Yellow
			Green	Light Emerald Green
		Mixed Polyester	Red	Crimson Red
			Yellow	Light Golden Yellow
			Green	Very Light Emerald Green

Testing the Fastness of Colour

Colour fastness to sunlight

Combination	***Nature of the fabric***	***Day 1***	***Day 2***	***Day 3***	***Day 6***
Red N	Cotton	No change	Notable colour fading	Negligible Fading	Negligible Fading
Yellow N		No change	Slight fading	Slight colour darkening	Slight colour darkening
Green N		No change	Slight fading	Slight Fading	Slight Fading
Red N	Polyester	No change	Notable colour fading	Slight discoloration	Discoloration
Yellow N		No change	Notable discoloration	Colour darkening	Colour darkening
Green N		No change	Slight fading	Slight fading	Slight fading
Red S	Cotton	No change	Colour Darkening	Colour Darkening	Darkening
Yellow S		No change	No change	Slight Fading	Slight Fading
Green S		No change	Notable fading	Notable fading	Notable fading
Red S	Polyester	No change	Colour Darkening	Colour Darkening to Blackish Red	Uneven Colour Darkening to Blackish Red
Yellow S		No change	Negligible Fading	Slight Fading	Slight Fading
Green S		No change	Slight Fading	Slight Fading	Slight Fading

Colour fastness to soap washing and wet rubbing

Combination	***Nature of the fabric***	***Soap washing***		***Wet rubbing***	
		Change during soap wash	***Change after soap wash***	***Colour change in the dyed fabric***	***Colour change in the white cloth***
Red N	Cotton	No significant change	Significant change to Rust Colour	No change	Deep staining
Yellow N		No significant change	Beige Colour	Slight colour change	Deep staining
Green N		Significant Bleeding	Colour disappears fully	Slight colour change	Deep staining
Red N	Polyester	No significant change	Great change to dim Rust Colour	Slight discoloration	Slight staining
Yellow N		No significant change	Beige Colour	Slight colour change	Notable staining
Green N		Significant Bleeding	Colour disappears fully	Slight colour change	Slight staining
Red S	Cotton	Heavy bleeding	Slight change	No change	Deep staining
Yellow S		Light bleeding	Slight change	No change	Heavy staining
Green S		Bleeding	Colour disappears fully	Total Discoloration	Deep staining
Red S	Polyester	Heavy bleeding	Slight change	No change	Heavy staining
Yellow S		Light bleeding	Slight change	No change	Normal staining
Green S		Bleeding	Colour disappears Fully	Total Discoloration	Slight staining

RESULTS AND DISCUSSION

- The extraction of natural dyes was quite challenging.
- Even though the quantity of plant material taken was the same, the addition of triple amount of water was not enough for some as in case of Button Rose and Chrysanthemum extraction.
- At first, I selected the colours as Red, Yellow and Blue. But the availability of plant material for blue colour seemed rare. Although I tried with the flower of Rough cheff - *AchyranthesAspera*(Blue) which was available in and around our school area. When I dipped the cloth in its extraction, I observed the colour as Purple. During post dyeing water wash I can see no colour fixation at all. Hence I have to choose my third colour as Green.
- For preparing Green natural dye, I selected Lavender as the plant material and I got the result nearer to the desired one. For extraction, I have to grind them and boil to get maximum colour.
- In Red Synthetic dyed fabrics, there is an uneven dyeing. I have observed black colour patches Here and there
- In Green Synthetic dyed fabrics, dye fixation was very poor**.**
- Even though the colour of the extraction as well as the dyed fabric of Red extraction (Beetroot, Button rose) was bright red in colour, during post dyeing water wash I observed heavy bleeding ended in totally different and unexpected colour.
- Naturally dyed green fabrics got lime colour.

Testing for Colour fastness

- Light exposure seems to have more effect in fading than other conditions.
- Unexpectedly, Red colour was very poor to light fastness.
- Green colour has very poor fastness to soap washing and wet rubbing. Red colour stands next to green colour in poor fastness to soap wash.
- Fading was observed to be different especially the light exposure, the change ranges from slight and even to darkening.

- I want to know why red synthetic dye applied in mixed polyester shows undesirable colour.
- It is observed that the uptake of dye itself is poor in natural dyeing and so the fading (change) may not be noticeable in those dyed fabrics.
- ***In all the exposed conditions, yellow seems to withstand the colour better than other colours.***
- Red colour fades so fast, I believe it may be because the red colour components react by absorbing the blue ray, which in fact has a higher energy so that makes the red colour molecules changes (degrades) from time to time. This may be because object's colour is dependent on the range of wavelengths it absorbs.
- Dyes fade because light absorption and exposure to the air can slowly break down the chemicals that give them color. Generally the higher the wavelength of the absorbed light, the more likely it is to cause a pigment breakdown. This is because the energy of each photon in light is proportional to the wavelength (Energy of a photon = Planck's constant times wavelength). Red, orange, yellow and green wavelengths have a much lower energy than blue, indigo and violet wavelengths. Dyes fade in that order because the closer the dye's colour is to the red side of the EM spectrum, it absorbs higher energy waves (including UV rays which are the main culprit) while objects which look closer to the violet end of the spectrum absorb lower energy wavelengths.

CONCLUSION

My hypothesis ***"Red synthetic dye applied in mixed polyester is more colour fast (resistant to fading) than others"*** has not been proved.

The Era of colour as a luxury has been changed into necessity. The impact of low colour fastness may be emotional for customers, but incur huge loss for the textile industries. Industries are in unhealthy competence to deal with this recurring issue. So it is a need to know about the colour fastness of selected colours so as to maximize the preference opportunity of utilizing them during production as well as in application.

APPLICATION

- Colours are important in this attractive world. Colours are very important aspect in the home decoration field. Nowadays, most of the houses are seen painted in bright colours whether the interior or the exterior part of the house. This not only attracts the attention of people but also provides a relaxing atmosphere compared to the white.
- To understand which colour to use for particular purpose, we need to know its colour fastness (resistance to fading) properties.
- So I have undertaken this project to know the colour which is most resistant to fading.
- Colours have a major part to play in the fashion industry as well. Whether it is a traditional outfit or modern one, both are very colourful and look wonderful. Colours add glamour to an outfit.

FUTURE ENHANCEMENT

- I am not sure about the results that red fades the most as I have used the lighter colours such as Yellow, Green along with it. This is because the changes in lighter colours may not be easy to note and differentiate.
- Also my results with natural colours seem to be unexpected.
- I want to continue my project by employing the darker colours such as Black, Dark Green, and Blue. I need to ensure the dye quantity and quality as the standard by employing synthetic dyes.
- Once I come out with result of which colour is more prone to fading, I want to test the statement by employing the same colour in different dyeing environment such as pH, Fabric type, mordant type, dye source.

ACKNOWLEDGEMENT

"Gratitude is the sign of Humanity". it is not fulfilled without praising the Almighty, for providing me this opportunity and strength to do my project.

I would like to express my deep thanks to my Senior Executive Mrs.A. ParakathNisha and Correspondent Mr.A. Sathakkathullah for their constant support.

I would be more grateful to my Principal Mrs.R.Sameem M,Sc, B.Ed, PGDCA,, who gave me the golden opportunity to do this wonderful project and her valuable guidance.

I express my deepest sense of gratitude to Science Coordinator Mrs. M.Taj NishaM,Sc, B.Ed, BA and my teacher Ms. K.Murshitha Shirin B.Tech for their guidance and valuable suggestions and for their keen interest in the investigation and in the presentation of this report.

I would also like to thank my parents and friends who helped and motivated me a lot in finalizing this project.

REFERENCE

- https://www.wikihow.com/Make-Natural-Dyes
- https://youtu.be/hoR6w_j281I
- https://www.thespruce.com/how-to-use-liquid-fabric-dye-2146635
- https://www.marthastewart.com/1110589/fit-be-dyed
- https://www.sciencefocus.com/science/what-determines-the-colour-of-an-object/