IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

UTILIZATION OF TEXTILE YARN WASTE FOR DRINKING WATER POTS

Ms. Alpana Shah[1], Dr. Namrita Kola[2]

1. Associate Professor, S. M. Patel College of Home Science, Sardar Patel University, Vallabh Vidyanagar, Gujarat, India

2. Professor, P. G. Department of Home Science, Sardar Patel University, Vallabh Vidyanagar, Gujarat, India

Abstract

Textile industries in India are becoming a major ecological concern due to pollution creation in form of gaseous emissions, liquid and solid wastes. The waste generated by textile units is in form of post producer and post consumer. Post producer waste is produced during the manufacturing stage and dumped at landfill sites in large amount at the outskirts of cities. Usually this waste is seen as fiber, yarn, fabric and garment leftovers. As per environmental concern this waste can be managed by reduce, recycle, reuse and restore. To overcome the pollution created by these units a small research was carried out. Yarn waste was collected from textile units of Ahmedabad, Gujarat. The waste was segregated and mixed with potter’s clay as dough or sandwich layer and small pots were made by hand. Later on cooling effect and tensile strength was studied respectively in experiment.

Key Words*: textile industry, yarn waste, post producer, cooling, tensile strength.*

Introduction:

Gujarat is one of the major textile revenue generating state. The textile sector employs millions of women and men by direct or indirect mode. Textile industries in Gujarat are involved with fabric production, garment making as well as technical textiles sectors. Due to this, these units produce tones of solid waste, gaseous emissions and liquid effluents. Among this the solid waste occupies the landfill sites ultimately contaminating not only the soil but also the water and air of the nearby areas. Though many laws and reforms have been imposed to overcome these ecological issues still more efforts are needed to be done to overcome waste generation. In textile sector solid waste is produced by departments manufacturing fiber, yarn, fabric and garment. Textile waste is classified as post-producer and post-consumer. Post-producer waste is leftovers of the fabric or garment factories as dyed and undyed fibers, yarns, selvedges and fabric pieces in woven knitted and nonwoven forms. The post- consumer waste is produced by consumer while use or disposal. More novel approaches and researches should be developed to recycle and reuse this solid waste to be utilized in community. The textile waste can be utilized at its maximum by appropriately using its properties(like strength, absorbency, elasticity and flexibility), suitable technology and developing value added products at low cost. Technologies of composite materials could be a feasible solution for the textile waste valorization by using natural and synthetic fibers and fabrics(7). Pichardo has stated that use of natural fibers as a reinforcement in building materials, has advantages of low environmental impact, low cost, and wide range of applications in comparison to synthetic fibers. Cellulose fibers mixed into the concrete improve the thermal and acoustic insulation (8).

Significance of research:

Technological development in textile industry has resulted in newer fibers, novel approaches and large varieties of yarns and fabric. But it is also creating ecological threat through waste generation. To overcome this, recycle and reuse of the waste can be carried out. With this aim, a small experimental research was done .Textile industry waste yarns were mixed with potter's clay from which pots were made. Cooling effect and strength of pots were analyzed.

Methods and materials:

Methodology can be divided into following heads:

1. Making pots: Post producer yarn waste (discarded by textile units) were collected, segregated as cotton, polyester and lycra waste. These segregated wastes were mixed separately with potter's clay. Two types of pots were made (figure 1).

A. **Traditional method**: In this method waste yarns were mixed thoroughly with clay in the ratio of 1:20 and 1:40 followed by kneading and pots were made.

B. **Sandwich method**: Second types of pots were made by sandwiching a layer of waste yarns in between two layers of potter's clay. Firstly, clay was molded in shape of pots. Then a layer of waste yarns were adhered to the clay in wet state. Later on, again coating of clay was applied on the yarn layer. The ratio of yarn to clay was 1:60 and 1:100. Small pots of 6cm height and5.5 cm circumference were made by hand in the laboratory. The pots were dried at ambient temperature and baked in muffle furnace at 250^{0}C for 3hrs. Pot with lycra yarns was made but as cracks developed on it was discarded for further study.

2. Testing cooling efficiency of pots: After cooling the pots overnight, 50 ml of tap water was added in each pot. The temperature of water was 21.1 ^{0} C. The room temperature during testing was 18-20^{o}C. After 02 and 07 hours, the temperature of water was measured in each pot.

3. Testing strength of pots using strip method: Based on observations of first experiment, set of strips/ plates of clay were developed with sandwiching layer of same type of waste yarns (figure 2). These plates were developed with waste yarns sandwiched between two layers of clay in ratio of 1:20, 1:15, 1:80, and 1:135. Strips/plates of clay were 25mm thick, 80mm wide and had gauge length of 50mm. All four sides of the plate were packed tightly. The plates were dried at ambient temperature and then baked in muffle furnace at 250^{0}C for 3hrs and left overnight to cool. The clay strips were tested for tensile and compression strength, as per standards of testing at SICART (Sophisticated Instrumentation Centre for Applied Research and Testing),Vallabh Vidyanagar.

Below given is the notations used in pots and plates with various type of waste yarns

S.No.	Notation	Details
1.	S	Potter's clay(standard)
2.	C	Potter's clay with unbleached cotton yarn
3.	W	Potter's clay with bleached cotton yarn
4.	B	Potter's clay with denim cotton yarn
5.	P	Potter's clay with lycra yarn
6.	L	Potter's clay with polyester yarn
7.	SCJ	Potter's clay with sandwich cotton and jute yarn
8.	SC5	Potter's clay with sandwich cotton yarn
9.	SC20	Potter's clay with sandwich 20gms cotton yarn
10.	SP	Potter's clay with sandwich polyester yarn
11.	SL	Potter's clay with sandwich lycra yarn

FIGURE 1 : CLAY POTS

FIGURE 2: CLAY STRIP SPECIMENS

Formula for calculations:

Tensile strength = $\frac{Tensile\ Load}{Cross\ sectional\ Area} = \frac{T}{W*t}$

Where,

T= Tensile load

W = width of the specimen

t = Thickness of the specimen

Standard pot/plate, cooling/tensile strength value was considered as 100%

All other specimen readings are calculated with reference to standard

Formula:

$$A = \frac{\text{specimen difference in cooling temperature/tensile strength}}{\text{standard difference in cooling temperature/ tensile strength}} * 100$$

Percentage Difference = A – 100 (Comparing with standard specimen values)

Results and Discussion:

Clay is a natural product present in earth and developed by decomposition of rocks due to water erosion. Basic mineral of pottery clay is kaolinite, Clay is composed of 40% aluminum oxide, 46% silicon oxide, and 14% water. There are no harmful by-products resulting from the production of pottery. Main reason to use clay for drinking water pots is its molding ability, softness and stickiness properties when wet, hardening at higher temperature and ability to make water cool due to evaporation. Studies show that fibrils in natural fibers like cotton regulate the absorption and release moisture thus making it as breathable fiber. On the other hand, Polyester and lycra are water-repellent so moisture evaporates from skin instead of penetrating into the fabric. Thus, it was thought that fiber reinforced clay will impart higher cooling.

The results show that drinking water pots with yarn wastes mixed in them shows higher cooling than that of drinking water pots without textile fibers. This can be due to capillary action of cotton and insulating property of polyester and lycra Water in pots with waste yarn insertion shows minimum 2.2^{0}C to 3.3^{0}C more cooling than regular drinking water pots within 02 hours.

This suggests that water pots with yarns gives faster cooling to drinking water. Observations after 02 hours depicts that cooling temperature was lowest in polyester / sandwich polyester> cotton jute / sandwich lycra> sandwich cotton(20gms)> cotton (unbleached)> cotton(bleached)/cotton(denim)/ sandwich cotton(5gms)> standard pot i.e. mixing or sandwiching of polyester yarns in potter's clay results in higher cooling of water(chart 1). The reason can be the wicking property of polyester fiber wherein the moisture travels on the surface of the yarn and not entering the fiber structure or clay composition.

After 07 hours, the cooling was more in polyester/sandwich polyester/ sandwich lycra> sandwich cotton (20gms)> cotton jute/ cotton (unbleached)/sandwich cotton(5gms) > cotton(denim)>cotton(bleached)> standard pot(chart 1). Increasing the amount of cotton yarns showed more cooling. Pots with polyester or lycra showed higher and similar amount of cooling. The reason can be hygroscopic nature of these synthetic fibers.

Temperature of tap water was 21.1°C

Sr. No.	Clay pots With fibers	Difference in cooling temperature(^{0}c)	Cooling Effect (in %)
1	S	1.1	
2	SCJ	3.9	+254
3	SC5	3.9	+254
4	SC20	4.2	+281
5	SP	4.4	+400
6	SL	4.4	+400

TABLE1: DIFFERENCE IN COOLING TEMPERATURE OF WATER AFTER 07 HOURS

All the pots with Sandwich layer of yarns show more cooling in temperature if kept for longer hours compared to pots with yarns mixed in dough of clay. This may be due to insulation of yarns between pot water and atmospheric temperature. Pots with lycra yarns mixed with potter's clay dough could not withstand baking temperature because at high temperature potter's clay shrinks and becomes compact whereas lycra molecules elongate, thus developing cracks on the pot and plate both.

The sandwich yarn pots showed more thermal stability. On the contrary the pots with fiber mixed dough developed cracks occasionally. To overcome this, pots with thick walls were made.

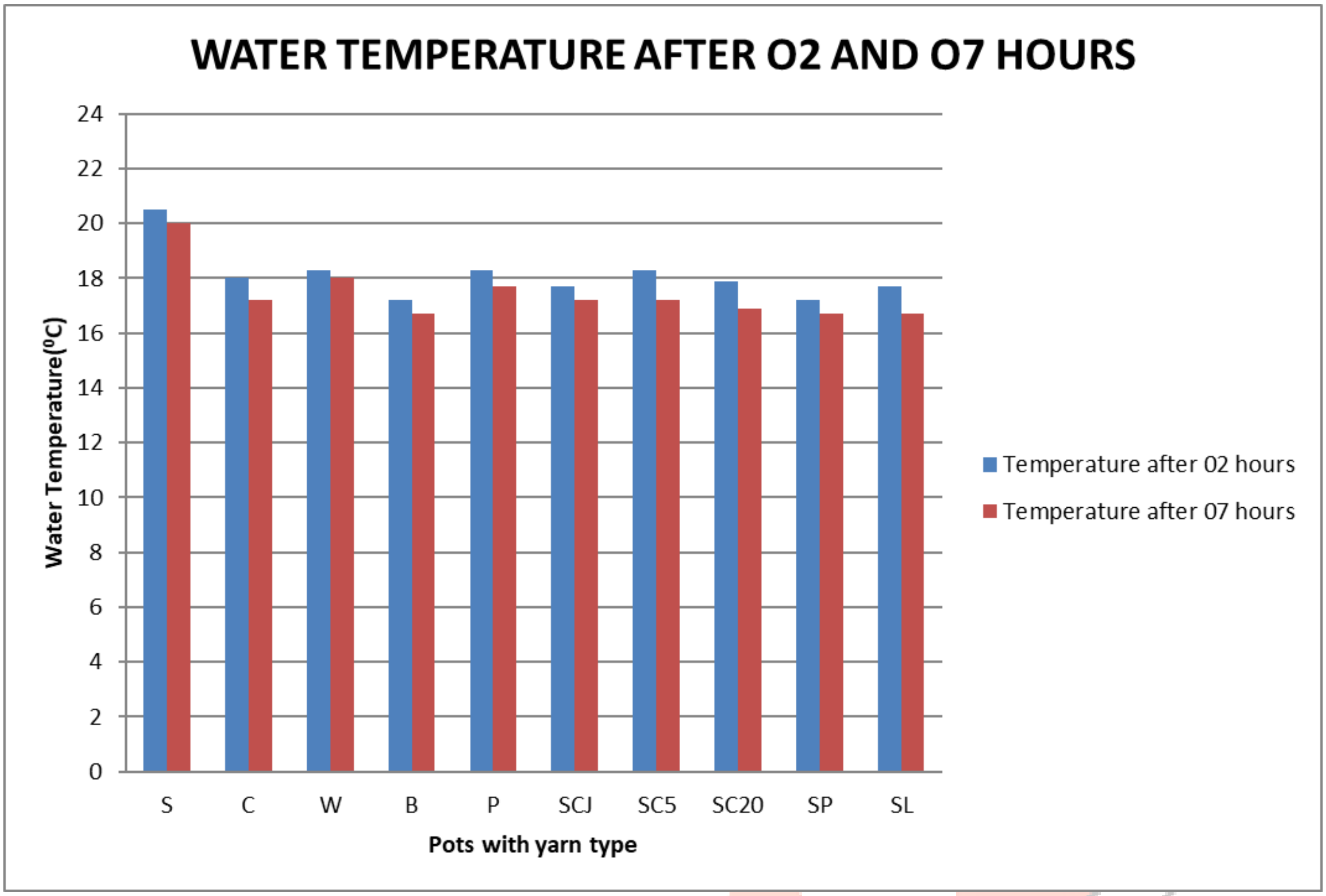

CHART 1. COOLING EFFECT OF DRINKING WATER POTS WITH DIFFERENT YARN WASTE (AFTER 02 AND 07 HOURS)

Based on results of cooling effect, further experiment was carried out to evaluate the tensile strength of the potter's clay incorporated with textile waste yarns as sandwich layer. Earlier experiment showed that sandwiching of waste yarns in drinking water pots resulted in faster and higher cooling of water but further tests showed reduction in tensile strength of plates on adding yarns in potter's clay (chart 2). After heating, plate made up of only potter's clay show more strength. The tensile strength was seen highest in plate with only potters clay> clay cotton jute sandwich> clay with cotton (5gms) sandwich>clay lycra sandwich>clay polyester sandwich>clay cotton (20gms) sandwich(Chart 2). The study shows that with increase in amount of cotton yarn there is steep decrease in tensile strength of plate. Dry cotton has low density with more air gaps but when it is sandwiched with wet clay this air gap reduces and strength reduces. On the other hand, polyester is a synthetic fiber. It doesn't bind with organic material like clay but occupies space. Furthermore it does not help in reinforcement of material, as a result decreases the tensile strength of the specimen. Sandwiching of lycra yarns in clay reduces strength by 45%. Lycra itself has low strength and high elasticity. But elastomeric fibers like lycra exhibit poor thermal properties. In this experiment, when plate with lycra is baked/ heated the strength and elastic properties of lycra plate reduces. Furthermore, as lycra yarns are cover spun it shows more tensile strength compared to cotton

(5gms) yarns. Plate with Cotton jute sandwich in clay shows comparative high tensile strength due to high tensile strength of jute yarns.

Sr. No.	Plate	Tensile strength(N/mm^2)	Tensile Strength (in%)
1	S	0.348	
2	SC J	0.2715	-21.99
3	SC 5	0.194	-44.25
4	SC 20	0.0718	-79.36
5	SP	0.0895	-74.28
6	SL	0.191	-45.11

TABLE 2: TENSILE STRENGTH OF STRIPS AND DIFFERENCE WITH STANDARD SPECIMEN.

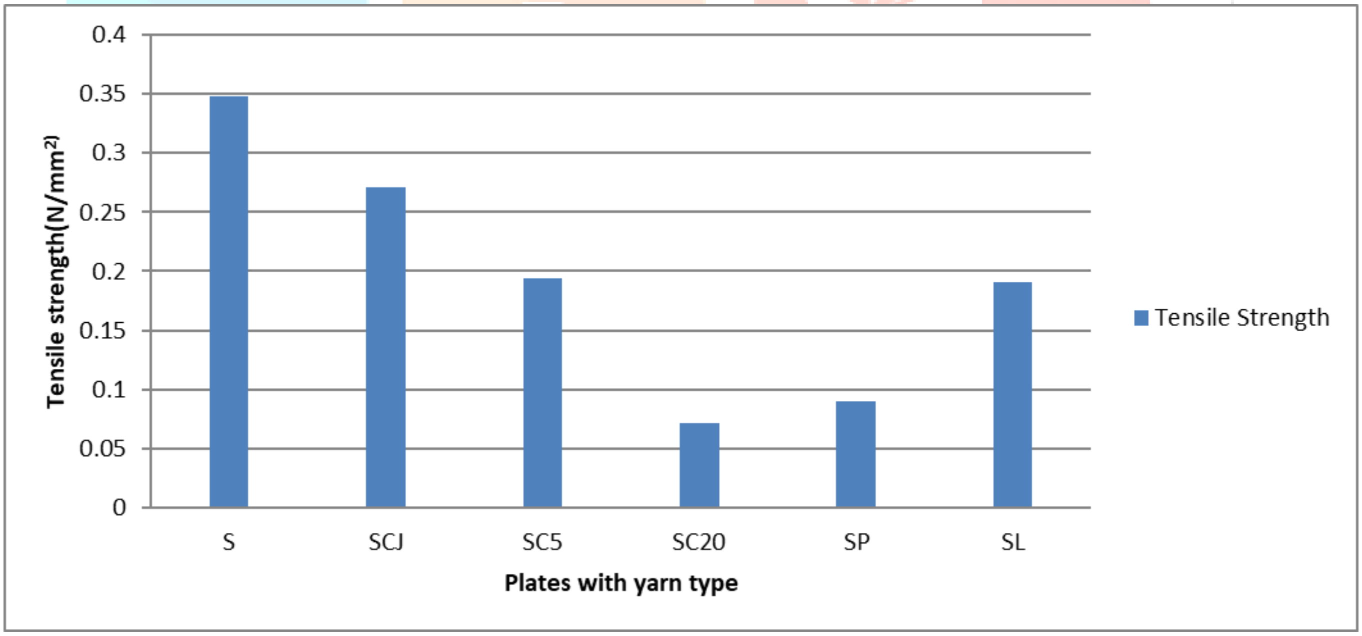

CHART 2: COMPARISON BETWEEN TENSILE STRENGTH OF CLAY PLATE AND PLATES WITH CLAY AND YARN

Conclusion:

The test observations indicate that mixing of waste yarns increases the cooling effect of drinking water pots compared to standard clay pots. Polyester yarns mixed with clay as dough or as sandwich layer shows the highest cooling(400%)(table 1) of water but on the contrary shows74% reduction in tensile strength(table2). Polyester is a synthetic fiber. Polyester exhibit wicking property for cooling water pots as well does not allow outer temperature to influence water temperature inside the pots. The drawback is that polyester fiber does not bind with clay.

The study also shows that with increase in amount of fibers in clay the strength of material reduces. Observations indicate that mixing of yarn in clay dough shows some amount of water seepage from the pots whereas the pots with yarns as sandwich layer showed less seepage. This property is due to porosity of textile fibers and the twists of yarn. The test results show that Lycra yarn sandwiching in potter's clay shows 400% higher water cooling and 45% reduction in tensile strength compared to standard clay. But clay with Lycra yarns on baking showed poor thermal resistivity i.e. clay with Lycra yarns is not suitable for final product.

In case of cotton waste yarns, with increase in quantity the clay plate strength decreases .Test results depict that clay pots with cotton yarns have 254% more cooling and 44% reduction in strength compared to standard clay pots.

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