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# Experimental Investigation on Utilizing Treated Dyeing Effluent in Utility Blocks

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**Abstract**

Utility blocks are most popular in construction due to their competent manufacturing and cost-effectiveness. However, traditional production methods require large amounts of potable water, which can create challenges in ensuring enough water for other construction needs. To address this, a novel approach has been developed that substitute treated dyeing industrial wastewater for potable water in the manufacturing of utility blocks. This method incorporates a bio-sorption process through a coagulation-sedimentation technique, using dry powdered ricinus as natural coagulants. Utility blocks were tested in compliance with IS 15658 standards. The mechanical properties of both conventional and effluent imbibed blocks were tested. The durability of both blocks was assessed by chloride penetration test. Empirical regression analysis was conducted to assess the compression and flexural strengths of blocks. The results from curing periods of 7, 14, and 28 days showed improvements in the strength. The modified blocks demonstrated increases in compressive strength of 1.76%, 2.01%, and 2.41% than conventional blocks. Flexural strengths also exhibited improvements, with increases of 14.8%, 13.62%, and 8.45% across the same curing periods.


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*Keywords:* Utility block; Dyeing industry effluents; Ricinus; Strength; Sustainability;

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## 1. Introduction

The ongoing evolution of construction and related tasks presents an insistent challenge: the growing demand for potable water to meet the requirements at various stages of construction. This situation has urged research into alternate solutions to confirm a satisfactory supply of water with good quality from diverse sources, including treated effluents that meet permissible quality standards. However, attaining water of exceptional potable quality remains a difficult task, often requiring the use of advanced technologies [Paul et.al. (2012), Waite et.al. (2005), Zhan and Sun Poon (2015), Banchero (2013)]. In the context of manufacturing utility blocks, the traditional use of reverse osmosis to purify water to meet drinking water standards may not economical. This is where bio-sorption offers a promising alternative and cost of treatment can be reduced up to 40% with respect to conventional treatments.

Bio-sorption uses natural or biological materials to remove contaminants from wastewater to generate water of adequate quality for utility block production. The incorporation of treated effluent in utility blocks presents several benefits [Raja and Arunvivek (2016), Amar et.al (2009), Bes-Pia et.al (2009), Arunvivek et.al (2014), Marcucci et.al (2001)]. Primarily, it allows the effective removal of contaminants and impurities from wastewater. Secondarily, bio-sorption is more eco-friendly associated with traditional water treatment methods [Noorjahan (2011)]. In many industrial regions, inappropriate discharge of effluents has become an environmental issue. By adopting bio-sorption technologies, it becomes possible to treat and reduce the impact of wastewater discharge, mitigating environmental pollution and degradation [Yan et.al (2018), Hussain and Wahab (2018), Stone et.al (2020)].

By exploiting unconventional water sources, industrialists can condense the usage of potable water and decrease their environmental footprint. Generally, the implementation of bio-sorption method in the production of utility blocks consequences in quality assurance and sustainability in the construction practices [Tang and Chen (2002), Asadollahfardi and Mahdavi (2019)]. This paper emphases on reconnoitering the possibility of utility blocks permeated with treated wastewater, entirely substituting potable water without reduction in strength [Duarte et.al (2019), KsenijaJankovic et.al (2012), Arunvivek et.al (2016)]. Ricinus offer promising resources for eco-friendly coagulants that facilitate bio-sorption, thereby yielding high-quality water suitable for construction activities. [Ashogbon et.al (2008), Dharmalingam et.al (2011), Peighambarzadeh (2020)].

## 2. Methodology of the study

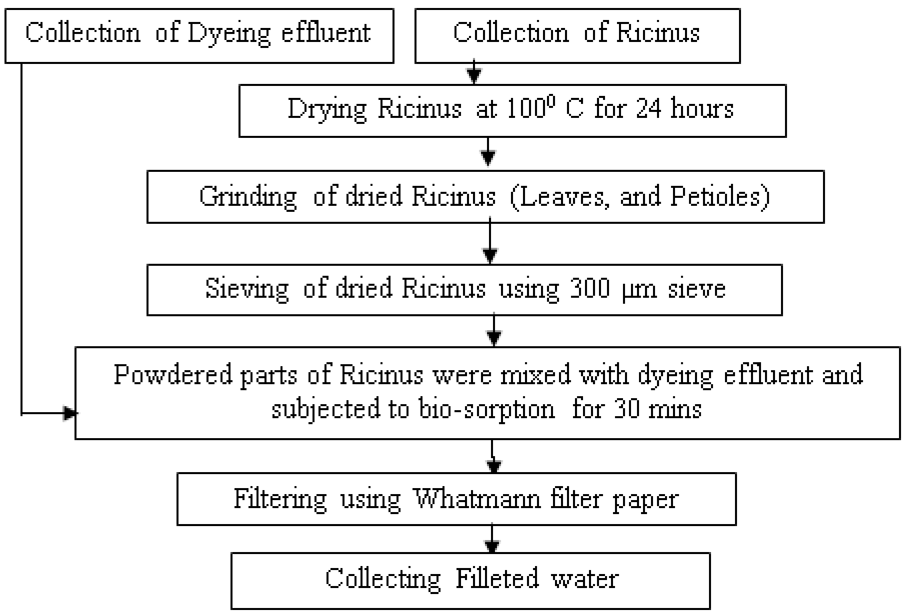


Fig. 1 Methodology of the study

## 3. Results and Discussions

Dried Ricinus was used as coagulant in the dosages of 20 g/L, 25 g/L, 30 g/L, 35 g/L, 40 g/L, and they subjected to bio-sorption for a contact times of and 30 mins. TDS of untreated effluent found to be 6812 ppm. The TDS content of effluent treated with Ricinus in the dosages of 20 g/L, 25 g/L, 30 g/L, 35 g/L, 40 g/L found to be 4452 ppm, 3149 ppm, 2281 ppm and 2197 ppm respectively. Beyond 35g/L only slight reduction in TDS content has been observed. Hence 35 g/L has been considered as optimal dosage. The cost of dried ricinus is around ₹15 per kg.

### *3.1 Influence of treated water on porosity of utility blocks*

As per codal provisions [IS 15658:2006, IS 383:1970, IS 15658:2006] any utility block, should have a limiting porosity of only 6%. By and large, infiltration and seepage properties are hampered by the presence of minute sediments in blocks. Consequently, the use of treated water results in reduced water absorption and porosity, providing an added advantage by saving potable water, which is often costly. This study highlights the cost-effectiveness of using bio-sorption water, decreasing the need for potable water. Concrete paver block with a side length of 12 cm and a thickness of 5 cm, made with potable water, was used as a control. The block, with a surface area of 390 $cm^2$ and a volume of 2019 $cm^3$, was immersed in water for 24 hours. The dry weight was 4.72 kg, and the wet weight was 5.28 kg, resulting in a saturated porosity of 5.7%. The dry weight of the treated water added paver block was 4.78 kg, and the wet weight was 5.3 kg, resulting in a saturated porosity of 4.3%. In line with conventional paver blocks, the porosity is less, specifies that sediments of the biosorbed water reduces the water absorption. The utility blocks added with treated water are comparatively impervious deprived of conceding the load-bearing capacity. A controlled porosity of 7.1% was foun in conventional blocks. Whereas, biosorbed blocks obtained less porosity of 4.9%. This noteworthy decline in water absorption may be owing to the pore-blocking effect of bio sediments [Peighambarzadeh et.al (2020)].

### *3.2 Strength characteristics of Conventional and treated water added blocks*

The compressive strength after 3, 7 and 28 days curing of biosorbed paver block was calculated as 23.1 MPa, 25.3 MPa and 42.4 MPa. The conventional paver block at same curing intervals, showed compressive strengths of 22.7 MPa, 24.8 MPa, and 41.4 MPa were used as a control. The flexural strength values were recorded as 2.48 MPa after 3 days, 3.67 MPa after 7 days for biosorbed utility blocks, and 5.39 MPa after 28 days. In comparison, the flexural strengths of 2.16 MPa, 3.23 MPa, and 4.97 MPa were noted for conventional paver blocks at the respective intervals.

### *3*.3 Regression analysis

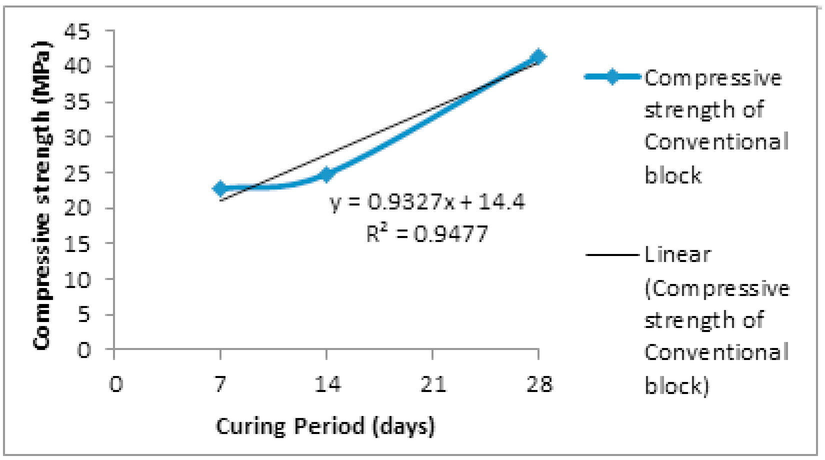


Fig 2. Compressive Strength Vs. Curing Spells of Conventional Blocks

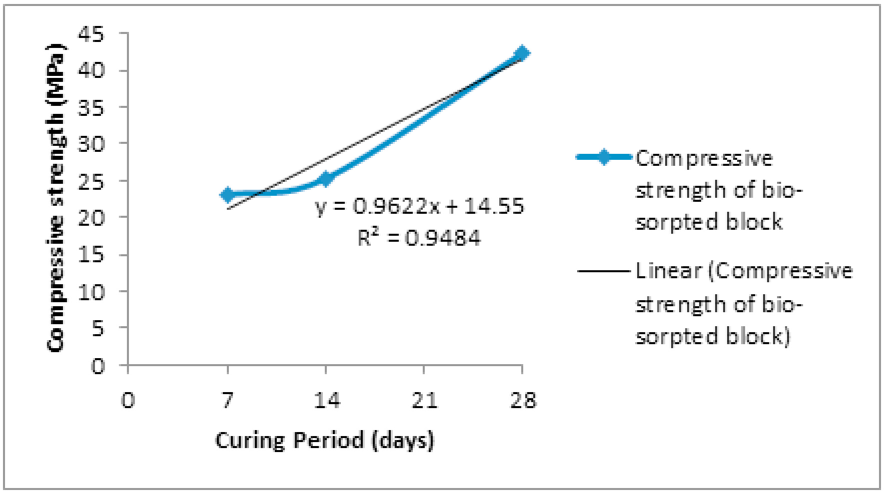


Fig.3. Compressive Strength Vs. Curing Spells of Biosorpted Blocks

To corroborate the comparative superiority of biosorbed utility blocks, the observations obtained from experimentation were related to regression analysis. The test results signposted that the relative increase in strength is more compared with daily increase. Time-dependent variations are represented using regression analysis by considering the synergy between variables. In this examination, reasonable linear trend with optimistic dependability was revealed by the regression modeling. The regression analysis for compressive strength of the biosorbed paver block yielded an empirical model $y$=0.9622$x$+14.55. This suggests an initial compressive strength of 14.55 MPa with correlation coefficient of 0.948. Fig.2 and Fig.3 shows the Compressive Strength variations with Curing Spells of Conventional and biosorpted Blocks. The experimental model established for the conventional block was y=0.9327x+14.4 having correlation index of 0.947. This represents an early compressive strength of 14.4 MPa which was marginally lower than that of the biosorbed block. Conversely, early escalation in strength for the conventional block was marginally more at 0.947 MPa per day. This recommends that the existence of dry bio materials might to some extent hamper the rate of strength gain of biosorbed blocks.

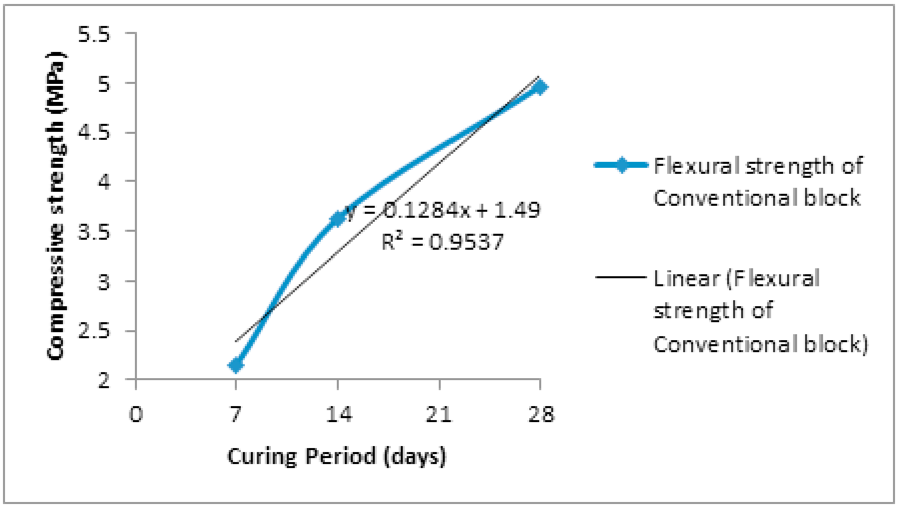


Fig.4. Flexural Strength Vs. Curing Spells for Conventional Utility blocks

An empirical model of $y$=0.1322$x$+1.77 was developed for the flexural strength of the treated effluent permeated paver block, with a dependable correlation coefficient of 0.976. This suggests an early flexural strength of 1.77 MPa, with a daily rate of upsurge in strength of 0.132 MPa. Fig.4 and Fig.5 shows the flexural strength variations with

Curing Spells of Conventional and biosorpted Blocks. The pragmatic model established for the conventional concrete block was $y$=0.1284$x$+1.77, with a correlation coefficient of 0.9537. This signposts an early compressive strength of 14.4 MPa, marginally lower than that of the treated effluent instilled block. However, early rise in strength for the conventional block was little higher. This recommends that the incidence of dry bio materials might slightly impede the rate of strength gain.

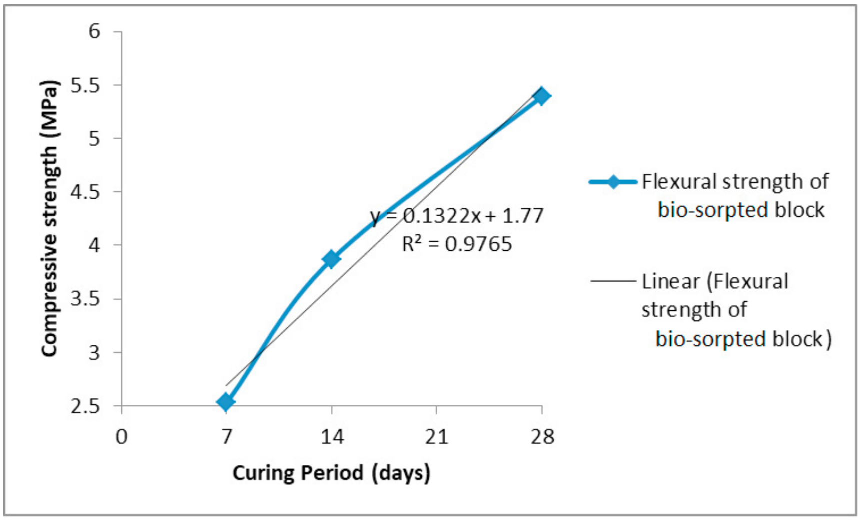


Fig.5. Flexural Strength Vs. Curing Spells for Biosorpted Utility blocks

### *3.3 Chloride penetration resistance of control and treated water added blocks*

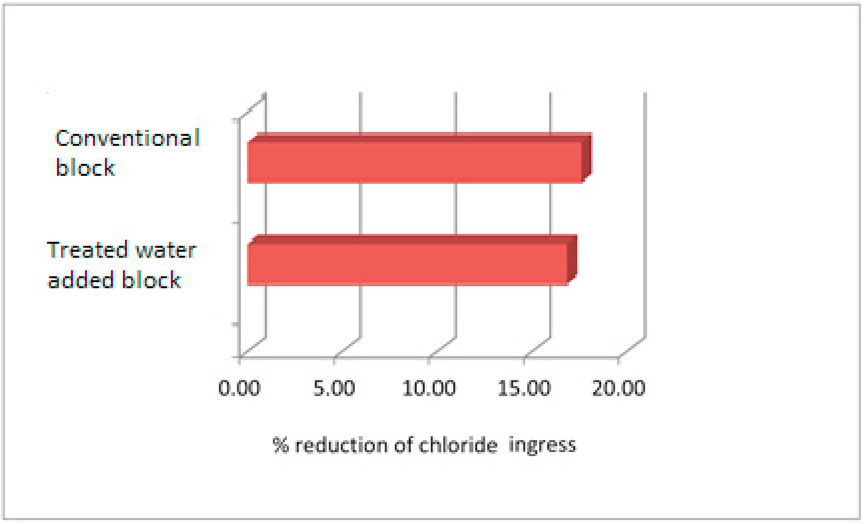


Fig. 6 chloride ion ingress of control and treated water added mix

The Rapid Chloride Permeability Test (RCPT) results were scrutinized for both the control blocks and the treated water incorporated improvised blocks. The control block unveiled the maximum chloride ion penetration, with a charge passed value of 1586 coulombs. In contrast, the blocks comprising treated water confirmed considerably enhanced resistance, with progressively lower coulomb values conforming to presence of fines in the matrix.

Experimentally the chloride ingress has been test verified through RCPT and the charge passed value of blocks comprising treated water recorded as 1467 coulombs, Fig. 6 illustratess the percentage reduction in chloride ingress relative to the control mix, with treated water imbibed blocks showing a noteworthy decrease. This reduction highpoints the efficiency of treated water imbibed blocks in augmenting its durability. The fines present in treated water filled the pores and densified the concrete. This condensed porosity and drops permeability, restrained chloride ion ingress and thereby improved the block's resistance and mechanical properties(Asadollahfardi and Mahdavi, 2019). Fig. 6 shows the preparation of specimens for various tests.


Fig.6 Prepared specimens

## 4. **Conclusion**

Overall, this investigation serves as a stepping stone in the trial-and-error process of determining the relative strength dependency of improvised paver blocks with the addition of treated water in place of potable water. The results, confirmed by both experimentation and regression analysis, indicate that replacing potable water with treated water does not produce any adverse effects. Biosorbed blocks obtained less porosity of 4.9% than conventional blocks. The chloride penetration test clearly revealed the durability potential of the treated water added block which has 7.5% lesser chloride ingress than the conventional block. 35 g/L of Ricinus powder can be considered as optimal dosage for treatment of wastewater. Therefore, it is concluded that 100% savings on the usage of potable water can be achieved by simply replacing it with treated water, without detriment to the structural and functional aspects of paver blocks compared to conventional paver blocks.

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