Influence of STP Treated and Reed Bed Treated Domestic Wastewater on Properties of Mortar and Concrete Mixes

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Abstract - *Polishing pond with gravel bed was constructed and planted with Canna generalis plants for treating the effluent from conventional domestic wastewater treatment plant. Raw sewage, treated effluent from S T P (Sewage Treatment Plant) and effluent from polishing pond were taken for analysis. Standard consistency, Early setting time and strength of cement, workability(in-terms of slump) and Compressive strength of concrete were determined using normal tap water, treated effluent and polished effluent. From analysis of effluents, it is seen that, characteristic values obtained for various parameters (for all wastewater types) are well within the acceptable limits as per water quality standards of BIS (Bureau of Indian Standards) for construction practice. There is clear reduction in normal consistency and initial setting time values for treated effluent and polished effluent as compared to normal tap water. An increment of 29% in 3 day compressive strength of cement has been observed for combination of polished water casting-fresh water curing as compared to fresh water casting and curing. For 7 and 21 days of curing, treated water casting-fresh water curing combination gives an increment of 16% and 11% in compressive strength as compared to fresh water casting and curing respectively. For increase in w/c ratio's lower slump values have been observed for treated water and polished water as compared to fresh water but except for w/c ratio of 0.6 for polished water. With 0.6 w/c ratio for polished water, little higher value of slump has been noticed when compared to fresh water. Though 7 days compressive strength of concrete for polished water casting-fresh water curing is 40% more than fresh water casting-fresh water curing, the 28 days strength for both of these cases are almost same. It is observed that for longer duration of curing of 90 days, all combinations are giving almost same compressive power of concrete. Samples casted with treated water, cured with fresh water shows slower development of strength at early ages, but for 90 days of curing shows higher strength than fresh water casting-fresh water curing.*

Keywords— *Reed bed, sewage treatment plant, wastewater, Canna genaralis, mortar and concrete*

I. INTRODUCTION

The usage of treated wastewater becoming progressively more important means of supplementing water supply requirements and reducing costs.The need for augmented water necessity for the increasing population is usually supposed, without bearing in mind whether obtainable water resources could meet these requirements in a sustainable manner. To address fulfilment of increasing water demand, lead to attempt the present strategies of wastewater reuse. However different strategies have given many approaches of making realistic use of available water. The new glance perpetually aims at reprocess and reuse of wastewater that is being more and more generated due to swift expansion of population and associated developmental actions, including cultivation and industrial outputs. Use of water reclaimed by various treatment processes is a challenge because around 80% of water used for various purposes is transformed into sewage and disposed into land and water bodies, which is wasted and leading to affect public health. In present situation, with existing potable water sources and eternally growing demand for water in different sectors, there is an urgent need to preserve water and to expand alternative resources. Water unfit for human consumption may be useful in industry and construction [1][28].

Water utilized for making cement and restoring will be shimmering and liberated from bothersome measures of oils, salts, acids, soluble bases, sugar, natural mixes or different substances that might be unsafe to concrete [2]. [3] Have brought up the impact of lead in blending water on adequacy, compressive quality, setting seasons of rich concrete mortar. Elevated concentrations of lead in water, had exposed significant decrease of strength, also setting times had considerably amplified. The use of treated waste water in concrete making did not influence properties such as shrinkage, segregation, water absorption, setting times and bulk density. These investigations direct the usage of various reclaimed waste water in construction and industrial activities [4]. Freshwater and treated wastewater was used in concrete works in Saudi Arabia and test results were compared. Compressive strength and Setting time were measured for cement and the results indicate treated effluent met the required standards for concrete making [5]. [6] Reported that there is a demand for supplementary research in recycle of squander water in concrete industries is required and most likely in prospect there will be a assertion of wastewater reuse in concrete production. [7] Suggest that treated squander water could be used for concrete making, as the blend can accomplish over 90% of the necessary strength. Many studies have expansively evaluated the usage of wastewater in concrete making in small scale. These studies have analyzed various squander water types such as fresh sewage and treated domestic effluent [8]. Excellence of mixing water plays a crucial role in making concrete [9]. Potable water can be used for making of concrete. In light of the set rules for water to be utilized for concrete making, the auxiliary treated household effluent is suitable for concrete making [10].

A range of sources of contaminated water such as sea water, alkali water, waste water from mining, mineral water, water enclosing sewage and industrial waste run-off, oily water and briny water from oil wells are checked for their suitability for using in concrete works [11, 12]. Cement mortar cubes were prepared by using magnetic field treated-water and drinkable water and tested for their compressive power. Remarkable increase of strength was noticed for the cubes those were casted using "magnetic field treated water" compared to those set with normal tap water. It not only reduces the quantity of cement used but also excludes addition of chemical admixture [13]. Compressive power of concrete cubes prepared by using recycled household wastewater has reduced 10% of compressive power but improved water impermeability contrast with control mix [14]. No detrimental effects were noticed when tertiary treated wastewater is used in concrete mix [15]. Setting time and compressive power of concrete was not altered when recycled water was used for experiment [16]. weighty metals like Cu, Ni, Zn, and Pb in integrating water are no undesirable effect with cement-mortar till concentrations of 600 mg/L [17]. The power of concrete prepared with squander water as mixing water is analogous with the vigour of control mix and moreover, the water amalgamation capacity of material was not affected when squander water is used as mixing water [18]. Concentration of lead in assimilation water for cement works is acceptable up to of $2x10^3$ mg/L [19]. To use contaminated water in concrete works, careful study on allowable limits of various parameters in mixing water is necessary. By sustaining the "appropriate alkalinity" in water, the pH will remain at requisite levels (7.2 and 7.6) [20, 21]. For the present study, samples were taken from the sewage treatment plant and polishing pond which are located near boys' hostel of our institute (NMAMIT). The aim of providing polishing pond is to further improve the quality of waste water released from STP which is considered as tertiary treatment process. Polishing pond consists gravel bed planted with Canna generalis plant with proper inlet/outlet arrangements.

II. METHODOLOGY

A. Sampling process

Samples were collected in separate sampling cans at peak hours (9:00am, 12:00 noon)

Following locations of treatment plant were used for sampling

a. Bar screen of treatment plant which is termed as raw sewage.

b. Treated effluent tank (Raw sewage undergone treatment through STP) considered as treated effluent.

c. Treated effluent undergone further treatment through polishing pond called polished effluent.

B. Analysis of effluents

Samples were tested for "Total Solids (TS), Total Dissolved Solids (TDS), pH, Nitrates, Chlorides, Dissolved Oxygen(DO), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Sulphates and Hardness" . Twelve samples were tested and analyzed for each type of effluent.

C. Consistency, setting time and compressive power of cement

Normal consistency and setting time tests were performed in parallel for different types of waste water samples with a standard Vicat mould. For testing of compressive strength of cement, moulds of size 70.5x70.5x70.5 mm were used with mix percentage of 1:3 (cement : sand) by weigh batching. Cement mortar cubes were casted by mixing with different water samples and compressive power was determined after 3, 7 and 21 days of immersion curing with different types of water.

D. Slump and Compressive Power of Concrete

For slump test, 1:2:4 (cement, sand and coarse aggregate) proportion was used by weigh batching by varying the quantity of water as per varied water cement ratio. For conducting compressive strength test on concrete cubes, standard cubical metal moulds of size 150 mm side were used as per specifications with mix proportion 1is-to 2 is-to4 and w/c ratio as 0.6. Nine sets of combinations were decided to cast the cubes .Cubes were casted by adding fresh water, treated water and polished water and experienced after 7, 28 and 90 days of water curing with dissimilar water types.

Following combinations were used for study of compressive power of cement and compressive power of concrete.

i) Fresh water casting fresh water curing
ii) Fresh water casting treated water curing
iii) Treated water casting fresh water curing

iv) Treated water casting treated water curing
v) Polished water casting fresh water curing
vi) Polished water casting polished water curing

III. RESULTS

A. *Tests on waste water/treated water types*

TABLE I.
EFFLUENT QUALITY PARAMETERS

Sl. No	Parameters	Raw sewage	Treated effluent	Polished effluent
1	pH	6.48	6.65	7.78
2	Total dissolved solids (mg/l)	373.33	231.11	360.00
3	Total solids (mg/l)	545.83	373.33	356.00
4	Nitrates (mg/l)	28.04	3.16	2.82
5	C O D (mg/l)	449.09	72.00	51.20
6	Dissolved oxygen (mg/l)	1.94	4.16	5.07
7	Chlorides (mg/l)	109.84	100.64	99.99
8	Total Hardness (mg/l)	108.00	96.00	104.00
9	Sulphates (mg/l)	7.70	8.30	10.30
10	B O D (mg/l)	352.00	27.00	17.33

TABLE II.
COMPARISON OF RAW SEWAGE, TREATED AND POLISHED EFFLUENTS (CONSTRUCTION PURPOSE)

Sl. No	Parameter	Raw sewage	Treated effluent	Polished effluent	Construction activity IS:456 (2000)
1	Total Hardness (mg/l)	108.00	96.00	104.00	440 mg/l
2	Total Dissolved Solids (mg/l)	373.33	231.11	360.00	3200 mg/l
3	Sulphates (mg/l)	7.70	8.30	10.30	400 mg/l
4	Chloride (for PCC) (mg/l)	109.84	100.64	99.99	2000 mg/l
5	Chloride (for RCC) (mg/l)	109.84	100.64	99.99	500 mg/l
6	pH	6.48	6.65	7.78	Not less than 6

TABLE III.
NORMAL CONSISTENCY AND INITIAL SETTING TIMES

Water type	Fresh water	Treated effluent	Polished effluent
Normal consistency	42%	40%	38%
Initial setting time	128 minutes	120 minutes	110 minutes

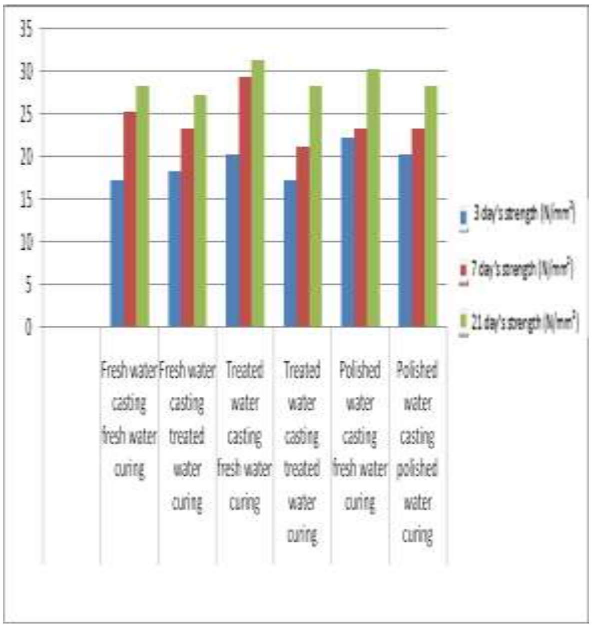

Fig. 1. Comparison: Compressive strength of cement

TABLE IV.
COMPRESSIVE STRENGTH OF CEMENT

ID	Combinations	Compressive strength (MPa)		
		7 day	14 day	21 day
A	Fresh water casting fresh water curing	17.10	25.14	28.17
B	Fresh water casting treated water curing	18.11	23.13	27.16
C	Treated water casting fresh water curing	20.11	29.17	31.19
D	Treated water casting treated water curing	17.10	21.13	28.16

E	Polished water casting fresh water curing	22.13	23.14	30.18
F	Polished water casting polished water curing	20.12	23.13	28.17

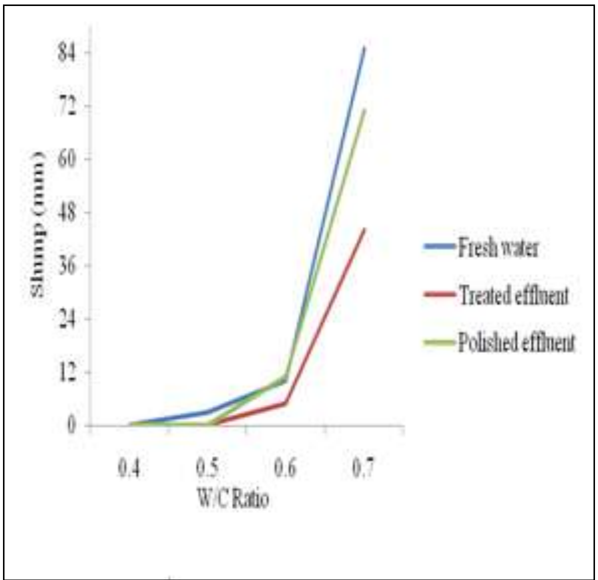

Fig. 2. Comparison: Slump v/s W C Ratio

TABLE V.
SLUMP VALUES FOR DIFFERENT WATER SAMPLE

W/C Ratio	Slump (mm)		
	Fresh water	Treated water	Polished water
0.4	0	0	0
0.5	3	0	0
0.6	10	5	11
0.7	85	44	71

TABLE VI.
COMPRESSIVE STRENGTH OF CONCRETE OF DIFFERENT COMBINATIONS

Designation	Combinations	Compressive strength (MPa)		
		7 day	28 day	90 day
A	Fresh water casting fresh water curing	20.44	33.78	34.67
B	Fresh water casting treated water curing	22.55	32.67	34.22
C	Treated water casting fresh water curing	20.22	29.78	36.89
D	Treated water casting treated water curing	19.99	28.22	35.33
E	Polished water casting fresh water curing	28.67	33.56	34.86
F	Polished water casting polished water curing	29.33	32.88	34.02

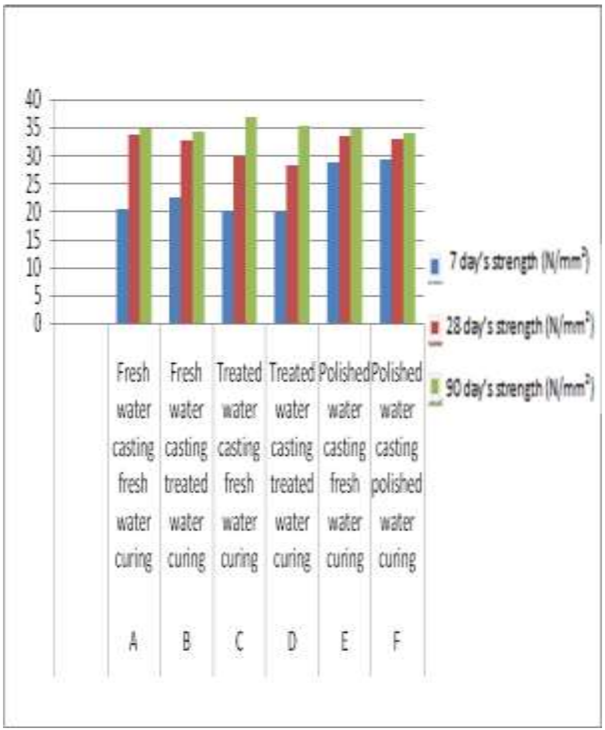

Fig. 3. Comparison: Compressive strength of concrete

IV. DISCUSSIONS AND CONCLUSIONS

A. Analysis of water samples

The pH value observed slightly low for raw sewage and treated effluent, due to putrefaction of organic substance in the water sample. The value increased in case of polished effluent, as the treatment proceeds, the pH tends towards alkalinity. Total dissolved solids decreased by 38% for treated effluent as compared to raw sewage. There is increase in total dissolved solid content in polished effluent which is due to the absorption of solids from reed bed material. There is 32% reduction of total solids in raw sewage compared to treated effluent. This value has been further decreased when sample undergone treatment through reed bed. Removal of Nitrates and COD are 89% & 84% respectively for treatment through STP. COD is reduced by 29% after polishing of STP treated effluent through reed bed system. It is observed that dissolved oxygen content improved during different stages of treatment processes and small reduction of chloride content is noticed as well. Marginal reduction of total hardness is observed for treated effluent. However totals hardness value increased when effluent treated through reed bed system due to absorption of minerals from filter media of reed bed. Remarkable decrease in BOD value is observed for STP treated effluent. A reduction of 36% BOD value is noticed when STP treated effluent treated through reed bed unit. This shows that the reed bed plants are efficient in absorbing residual putrescible organic matter from the effluent. From analysis of water samples, it is observed that the values obtained for various parameters (for all waste water types) are well within the permissible limits as per water quality standards of BIS for Construction Purposes

B. Analysis of performance of cement and plain concrete with different water samples .

There is a reduction in normal consistency and initial setting time for treated effluent and polished effluent compared to fresh water. .[22] and.[23] reported that the initial setting time would increase in case if treated domestic wastewater is used in making cement paste but it is not so for the samples used for the present study.

An increment of 30% of compressive strength of cement has been observed in 3 day curing for combination of polished water casting-fresh water curing compared to fresh water casting and fresh water curing. For 7 and 21 days of curing, dissipated water casting-fresh water curing gives an increment of 16% and 11% in compressive power as compared to fresh water casting and fresh water curing respectively. However as per [24], water is appropriate for concrete works if the mortar prepared with it has power after 7 days curing period is equal to or less than 10% decrease compared to study samples prepared with fresh water.

Lesser slump values have been observed for increase in w/c ratios in treated and polished water contrast to fresh water. Present study consequences indicate that the concentrations of dissolved solids in treated domestic wastewater reduce the slump value in concrete. Even though 7 day compressive power of concrete for polished water casting-fresh water curing is 40% more than fresh water casting-fresh water curing, the 28 days strength for both of these cases are almost same. It is observed that for longer duration of curing such as 90 days, all combinations are giving almost significant compressive strengths. Though cubes casted with treated water shows slower development of strength at early ages, for 90 days of curing shows strength greater than fresh water casting-fresh water curing.

[25] and [26] investigated that the chief dissolved solids in the solution stage are very significant aspects in leading the characteristics of early hydration of cement phase. The present results are not in divergence with [27] who highlighted that the concrete properties are not affected by using treated domestic wastewater. Present study results show that different type of treated wastewater can be incorporated for production of plain cement concrete. This intern not only helps in the waste water management but also provides value addition to waste water which will reduce the usage of fresh water for construction purpose.

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