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USE OF MUNICIPAL WASTEWATER FOR PLAIN CEMENT CONCRETE CONSTRUCTIONS

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KEYWORDS

Municipal wastewater, primary treatment, plain cement concrete, compressive strength, wastewater reuse, slump test

ABSTRACT

Reuse of Municipal wastewater is seems to be restricted for irrigation purposes only, whereas, the same can be used in plain cement concrete construction works without compromising the compressive strength. The only negative ingredient in municipal wastewater is the presence of sulphates. Four categories of water samples (Tap water, Primary Treated wastewater, 50%Tap water + 50% municipal wastewater and municipal wastewater) were used in the plain cement concrete cylinders which were tested for compressive strength, having 7, 21 and 28 days curing age. It was found that municipal wastewater after primary treatment, if used in the mixing process of plain cement, will give 209 Kg / cm2 whish is the required compressive strength of plain cement concrete. Therefore, Reuse of municipal wastewater in the construction works can save fresh water which is becoming scare day by day.

INTRODUCTION

Building construction and operation draw very heavily on water from the environment. Most of the water is located in the oceans and too salty for residential, industrial and for other all types of constructions. It is also highlighted here that building manufacturing material and building construction consumes 16% of the earth s" fresh water annually. Growth in urban water use/consumption is lowering water tables and necessitating large projects that siphon supplies away from the agriculture sector. Since the turn of the century, the world wide municipal use of water has grown 19 times and industrial use has grown 26 times. In contrast, the agricultural use has increased only 5 times. The subject statistics pertaining to water consumption will increase manifolds, thus highlighting the scarcity of water in the coming days.[1] Therefore, with these growing world wide concerns over increasing levels of water consumption and lack of adequate supplies, gray water technology has enjoyed increased popularity as a viable alternate to merely reducing water usages.[2]

There are various categories of concrete works which require huge quantum of water for mixing, where different types of cements, being the main component, are to be used to achieve the desired strength. The details of various types of cement are appended below, in which wastewater can also be used to make the fluid concrete.

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Rapid hardening, high-early strength, hydraulic cement is used in construction applications, such as fast-track paving, where fast strength. Sulphur cement is used to make sulphur cement concrete for repairs and chemically resistant applications. Sulphur cement melts at temperatures. Magnesium phosphate cement is a rapid setting, early strength gain cement. It is usually used for special applications, such as repair of pavements. Calcium aluminate cement is not portland cement-based. It is used in special applications for early strength gain (design strength in one day); Ettringite cements are calcium sulphoaluminate cements that are specially formulated for particular uses, such as the stabilization of waste.

The main objectives of this study were use of municipal wastewater alone and in combination, in plain cement concrete construction works and identification of civil works where municipal wastewater can be used without comprising structural strength parameters.

MATERIAL AND METHODS

In this regard, Municipal Wastewaterwas used for plain cement concrete (PCC) to ascertain its effects on the strength of concrete. Following types / ratios of MWW were used;

- 50 % wastewater & 50 % normal tap water
- Primary treated wastewater.
- Normal Tap Water

Municipal Wastewater Characteristics

Municipal wastewater, ex- Faisalabad city was selected for trials, which has the following characteristics;

Table 1. Parameters obtained from the analysis of various categories of Municipal Wastewater alone and in combination

Ss#	Parameter	Normal tap water	Primary treated water	Wastewater + normal water (50/50)	Wastewater
1	Conductivity (US/cm)	845	3075	5020	-
2	TDS (ppm)	676	2613	4267	-
3	Total hardness (ppm of $CaCO_3$)	275	450	550	-
4	Ca hardness (ppm of $CaCO_3$)	200	200	200	-
5	Mg hardness (ppm of $CaCO_3$)	75	250	350	-
6	P-Alkalinity (ppm of $CaCO_3$)	Nil			-
7	M-Alkalinity (ppm of $CaCO_3$)	275	800	750	-
8	SiO_2 (ppm)	20	35	25	-
9	Sulphates (ppm)	60	350	740	980
10	Chlorides (ppm)	80	425	860	-
11	COD (ppm)	12	18.8	18.8	-

Material and Equipment Used

- Port Land Cement
- Aggregates1.905cm and down.
- Sand.
- Water, Municipal Wastewater, Primary Treated Wastewater and 50% Tap Water + 50% Municipal wastewater.
- Additives.
- Cylinder Moulds (15.24 cm diameter * 30.48 cm high).
- Tamping Rod 1.58 cm diameter.
- Curing Tanks.
- Capping Apparatus.
- Capping compound (Sulfur and fine sand mixture).
- Compression Testing Machine.
- Scope.
- Trowel.

The trial to determine the compressive strength of concrete was carried out by preparing different cylinders for 7 days, 21 days and 28 days (curing periods). Following test results were obtained, which are appended below; [3][4][5][6][7]

Technical data

1.	Water cement ratio	0.64
2.	Water quantity	32 litters.
3.	Weight of cement	5 Kg
4.	Type of cement	OPC
5.	Slump	50 mm
6.	Workability	correct.
7.	Concrete ratio by vol	1: 2: 4
8.	Concrete temp	29^{o} C
9.	Weight of course aggregate 0.95cm down	140585 gram.

10. Weight of course aggregate 1.905cm down 50470 gram.
11. Weight of fine aggregate (sand) 105874 gram.

Trial results / tests are tabulated graphically are shown below;

Type of water	**Age (days)**	**Concrete temp**	**Slump**	**Ave comp str (of three trials) Kg / Cm**
Normal Tap water (TW)	28 21 7	29º C	50 mm	224 210 167
Primary treated wastewater (PT)	28 21 7	29º C	50 mm	216 203 161
50 % tap water + 50 % wastewater (TP+MWW)	28 21 7	29º C	50 mm	209 198 158
Municipal wastewater (MWW)	28 21 7	29º C	50 mm	176 166 130

Compressive Strenght-28 days age (Curing Time)

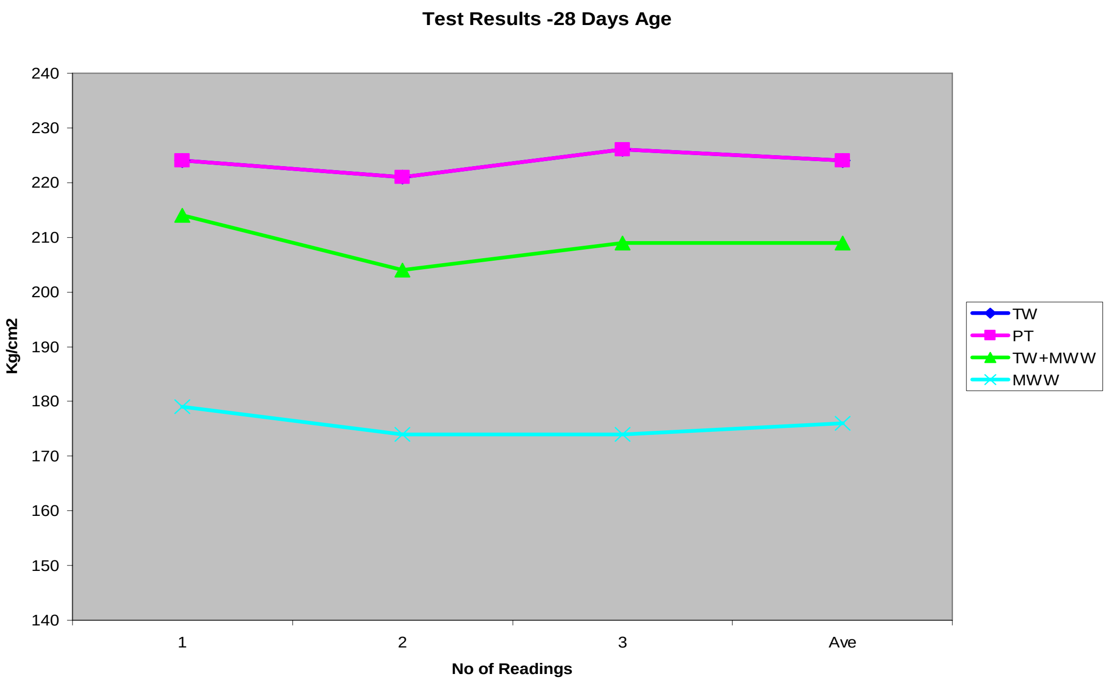

Figure 1. Graphical Representation of 28 days of concrete strength using all four categories of water

Compressive Strength – 21 days age (Curing Time)

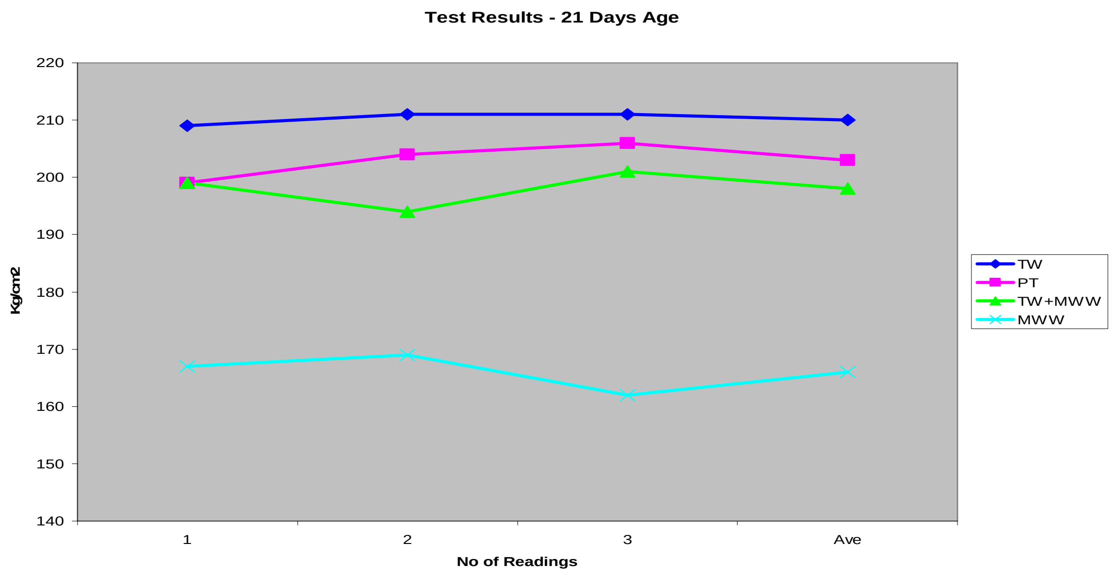

Figure -2. Graphical Representation of 21 days of concrete strength using all four categories of water

Compressive Strength- 7 day age (Curing Time)

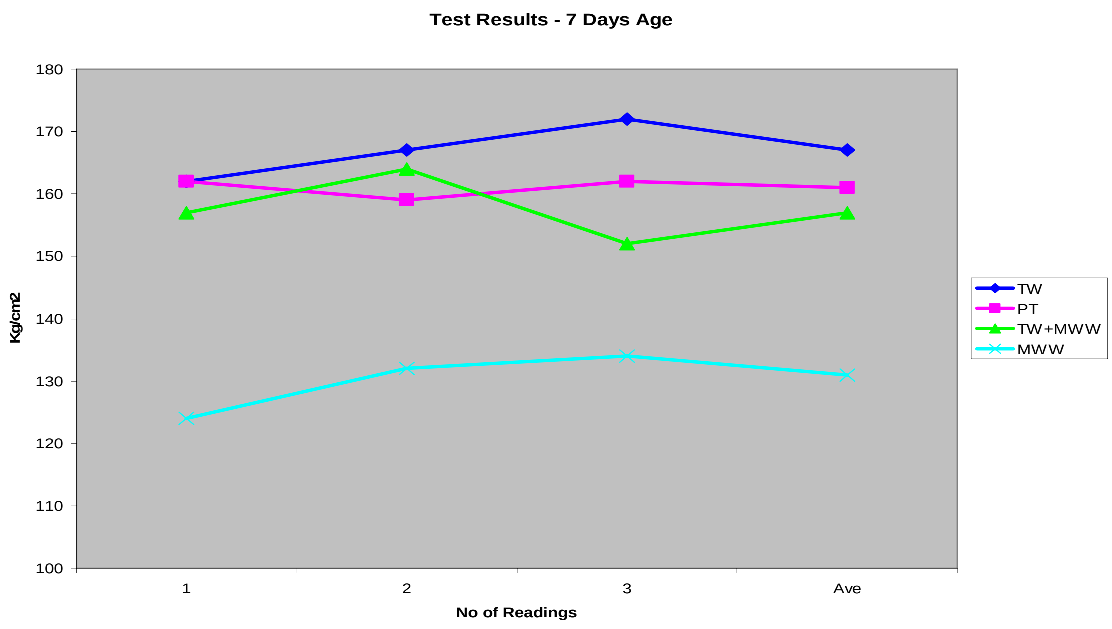

Figure -3. Graphical Representation of 7 days of concrete strength using all four categories of water.

Consolidated concrete compressive strength by using all the categories of wastewater for 28, 21, and 7 days curing time

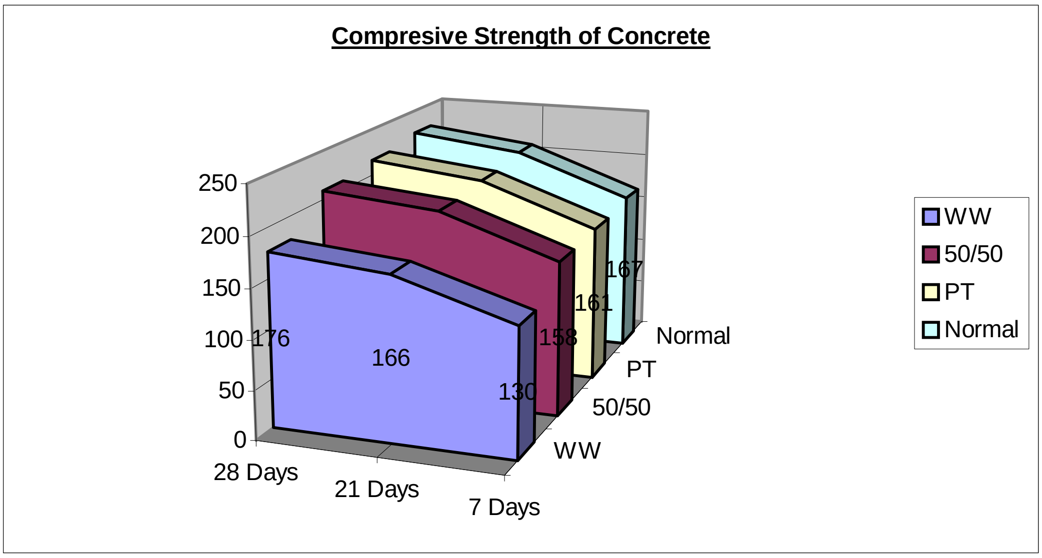

Figure-4a. Graphical Comparison of Concrete Compressive Strength

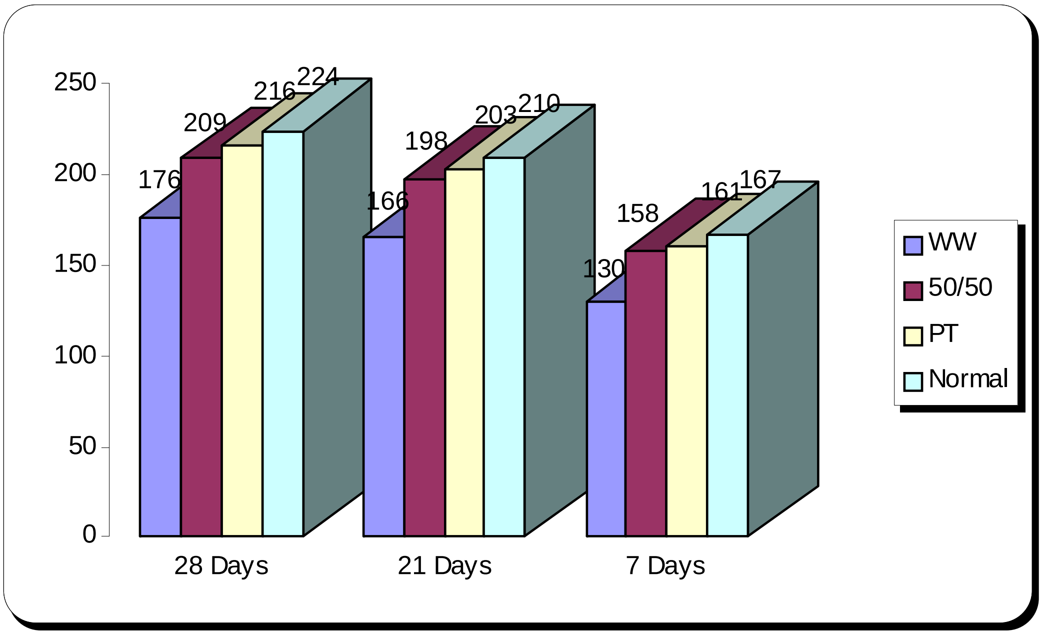

Figure-4b. Graphical Comparison of Concrete Compressive Strength

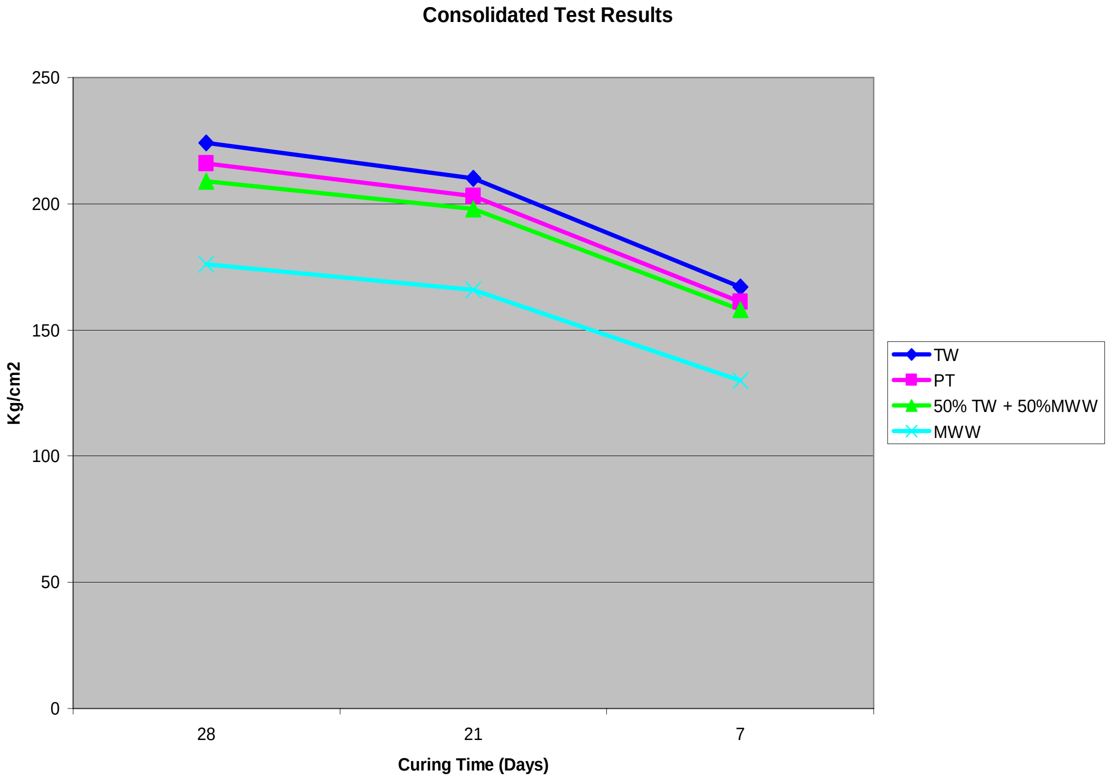

Figure -5. Consolidated test results.

RESULTS AND DISCUSSION

The comparison of compressive strength obtained through various trials envisages that the recommended minimum compressive strength of concrete is 210 Kg/cm^2 (3000 psi), and the compressive strength achieved by using primary treated water comes to be 216 Kg/ cm^2 (28 days curing) which is more than the minimum required compressive strength.

The compressive strength achieved by using municipal wastewater (MWW) is 176 Kg/cm^2 (28 days) which is less than the minimum requirement. The compressive strength achieved by using 50 % tap water and 50 %MWW is 209 Kg /cm^2 (28 days), which is very near to the minimum required compressive strength.

The sulfate constituents, found in the municipal wastewater, is the major ingredients that affects the strength of concrete, i.e. 176 Kg / cm^2 and 224 Kg / cm^2 for municipal wastewater (MWW) and normal tap water respectively. The wide range of compressive strengths emanating from different combinations of municipal wastewater (MWW) provides its uses in different concrete construction activities of various strengths / loadings requirements.

The planned use of wastewater in the construction industry can save world's 16 % fresh water, which is otherwise being used in the construction works.

Following points (which were noticed during the course of tests/trials) affect the concrete strength, which must be given due consideration while carrying out concrete tests and concrete works;

- W/C, curing time, porosity and strength
- Slump, water content, strength

- Type of failure, shear or cone
- Strength (i.e. compressive, tensile, flexural).
- Unit weight, air content and strength
- Cylinder geometry, moisture condition and strength
- Loading rate, capping material

From the critical analysis of the trials / tests, following relationships have been observed;

- The increase in sulfate concentration is inversely proportional to the compressive strength of concrete.
- The increase in dissolved solids concentration is inversely proportional to the compressive strength of concrete.
- The increase in curing time is directly proportional to the compressive strength of concrete.
- Increase in turbidity is inversely proportional to the concrete strength due to presence of impurities.
- Increase in chlorides concentrations is inversely proportion to concrete strength.

The characterization of wastewater shows presence of heavy metals in which might be harmful if used irrigation purposes, especially for vegetables and other food chain crops as well.

CONCLUSION

From the critical analysis of the trials, compressive strength of concrete beams prepared by using various categories of wastewater, shows encouraging results. Therefore, from the trials, following conclusions are made.

Compressive strength of Concrete cylinders/beams was checked by using four categories of water i.e. Tap water, primary treated wastewater, Municipal wastewater and 50 % MWW + 50 % Tap Water. The compressive strength of sample cylinders/beams was checked basing on the age of 7 days, 21 days and 28 days (curing periods).

The test results indicate that primary treated wastewater can be used in the plain cement concrete works which include, foundation works, and rigid pavements, for preparation of base /sub-base for road construction works, protective works and drainage works.

At the moment, 16 % of world‘s fresh water is being used for construction purposes which can be saved by utilizing wastewater. This will not only save the precious fresh water but will also provide an opportunity to manage the wastewater which is otherwise becoming a big environmental disaster for the humanity.

The un-controlled/un-managed wastewater has already contaminated the ground water aquifers in many areas of the world and this environmental de-gradation will continue till the time some useful usages of wastewater are not explored. For time being, the best utility of wastewater seems to be its consumption in the construction industry where chlorinated fresh water is being used at certain areas.

RECOMMENDATIONS

In the light of the conclusions drawn from the above study, following recommendations are made;

The use of primary treated wastewater for construction purposes in the cities should be made mandatory where lot of construction activities takes place. Legislation at local government level should be promulgated for strict compliance by the contractors.

A colored (preferably yellow) pipe line system of distribution of such treated wastewater be evolved in the form of fire hydrants. The same wastewater can also be used for irrigation of parks and green belts in the cities.

Further research should be undertaken for utilizing this primary treated wastewater for other concrete construction works, for reinforcement cement concrete, brick works and all types of ground and supper structures works.

A separate research should be conducted to use the treated wastewater for in marble industry for the processing of marble products which is highly water intensive.

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