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Effects of the Physico-Chemical Characteristics of Treated Wastewater Effluents on Their Reuse in Plain Concrete Works

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Abstract

The scarcity of water is fast becoming a critical environmental issue worldwide. Any effort targeted at conservation of this limited resources, preventing environmental degradation and thereby reducing water shortage, is worthwhile. This research therefore focused on the reuse of treated wastewater effluent in place of potable water in plain concrete production. The effects of the physico-chemical characteristics of this non-fresh water on the concrete strength were studied over time. Water samples were obtained from four sources which include: NMAM IT Nitte Campus potable water, Treated domestic sewage water, Service station water (Garage) and Dairy water. The samples were all analyzed for pH, total dissolved solids (TDS), chloride, hardness, alkalinity, and sulfates. Grade M20 concrete was adopted in the study. Physical tests conducted on the aggregates for the concrete mix include specific gravity, water absorption and sieve analysis. Plain cement concrete mixtures were prepared using Ordinary Portland Cement, graded aggregates and 100% substitution of treated wastewater for the mix. In all 12 concrete cubes were cast and cured for 3, 7 and 28 days. The mix ratios and compressive strengths of the cubes were determined using the Standard laboratory method of IS: 10262-2009. As compared with the USEPA and EU Standards, the general water pollution order observed was: Fresh water < Treatment Plant Effluent < Dairy water < Auto-Service effluent. The compressive strength result obtained from treated effluent showed an increase in 8.26 % for 28 days compared to fresh water. For garage water an increase in 5.14% was observed compared to freshwater. In general, there was no strength reversal with longer curing periods. However, for most concrete mixtures the strength tends to level off after one months of curing. Most production water mixtures resulted in higher strength measurements than those prepared using potable water. It was concluded that the physico-chemical parameters measured in the treated wastewater effluents had positively influence on the compressive strength of the plain concrete. From this study, it is believed that the recommended reuse of wastewater in plain concrete works will indirectly conserve the scarce water resources of the study area, as the regular sources would be concentrated on supply of drinking and other potable water usage.

Keywords: wastewater, effluent, reuse, concrete, compressive strength

INTRODUCTION

At present, there is paucity of information on the quality of water which is acceptable for use as concrete mixing water. The allowable impurities in concrete mixing water are compiled from the literature (Neville, 1997). Some of these limits are reflected in current standards which allow the use of recycled water. Ainul *et.al.,* 2012 made an attempt to study experimental findings regarding the feasibility of using treated effluents as alternatives to freshwater in mixing concrete. Samples were obtained from three effluent sources: heavy industry, a palm-oil mill and domestic sewage. The effluents were discharge into public drain without danger to human health and natural environment. Chemical compositions and physical properties of the treated effluents were investigated. Fifteen compositional properties of each effluent were correlated with the requirements set out by the relevant standards. Concrete mixes were prepared using the effluents and freshwater to establish a base for control performance. The concrete samples were evaluated with regard to setting time, workability, compressive strength and permeability. The results showed that except for some slight excesses in total solids and pH, the properties of the effluents satisfy the recommended disposal requirements. Two concrete samples performed well for all of the properties investigated. In fact, one sample was comparatively better in compressive strength than the normal concrete; a 9.4% increase was observed at the end of the curing period. Indeed, in addition to environmental conservation, the use of treated effluents as alternatives to freshwater for mixing concrete could save a large amount of freshwater, especially in arid zones.

Ooi *et.al.,* 2001 made the feasibility study of using treated effluent for concrete mixing was studied. Treated effluent from sewage treatment plants in Malaysia is currently being wasted through direct discharge into waterways. With proper water quality control, this treated effluent can also be considered as a potential water resource for specific applications. Two tests were carried out namely compressive strength test and setting time to determine the feasibility of using treated effluent for concrete mixing. The results were compared against the tests conducted on control specimens who used potable water. The results showed that treated effluent increases the compressive strength and setting time when compared with potable water. Recent literature *(*Lobo *et.al.,* 2003*)* focused on the use of partially treated sewage water.

Steinour, 1960 found the following: much larger contents of the impurities, in natural water, can be tolerated except for the alkali carbonates and bicarbonates which may have significant effects even at 2000 ppm; natural fresh water rarely contains more than 2000 ppm (0.2%) of dissolved solids, and is generally suitable as mixing water; water contaminated with industrial wastes, but free of suspended solids, appear also to be generally suitable at low concentrations; other inorganic impurities, of possible industrial origin, ones that may be detrimental at moderate concentrations are the sulfides, iodates, phosphates, arsenates, borates, and compounds of lead, zinc, copper, tin and manganese; seawater, although it contains 3.5% of dissolved solids, produces concrete with good early strength, but often somewhat lower later strength. Risk of corrosion of embedded metals limits the use of seawater in reinforced concrete; No general summary or tabulation in terms of maximum limits on impurities was attempted by Steinour as he considered the information to be inadequate. For the most part, the data were only strength data. Effect on un-investigated properties such as workability, long-time volume stability, and tendency to effloresce were unknown.

In another research, it was found that the effects of impurities in mixing water on concrete properties are as follows: Oil, fat or detergents make air entraining possible; Calcium chloride and some other calcium salts increase the probability of set acceleration; Sugar, salt or zinc, lead, and a range of other inorganic and organic materials enhance probability of set retardation; and also that Chloride ions give strong probability of steel corrosion.

Ojoawo and Oladejo, 2013 investigated into the effects of water contaminated with sodium chloride (*NaCl*) on the compressive strength of concrete. In the work, a mix ratio of 1:2:4 was employed for the concrete cubes (*150mm x 150mm x 150mm*), of which batching was by volume. The distilled water for the concrete mix was polluted with varying concentrations of NaCl which ranges from 0g of the salt/litre of water (*the control*) to 500g of salt/litre of water at an interval of 100g/litre. After curing for 7, 28 and 56 days, the compressive strength tests were measured. Findings revealed that for 0g of salt/litre, the initial strength was retarded in the first 7days, uniformly progresses through 28 days until the 56th day. For the contamination of 100g/litre, the trend of concrete strength is similar to the control. As the quantity of contaminated salt increases after this stage, the compressive strength generally decreases. It was further observed that the contamination effects were not pronounced on the strength within the first 7 days. Fresh concrete with higher salt concentrations (*exceeding 200g/litre*) however has elongated setting times *(corroborating the findings of Ryan et.al, 1992)*. The respective 56-day compressive strengths found for the 0, 100, 200, 300, 400 and 500g of salt /l of water were: 37.12, 37.15, 23.00, 24.68, 24.50, and 24.30 N/mm^2. The study concluded that the contamination effects of chloride salt on the compressive strength of concrete worsen with concrete age and thus should be prevented as much as possible.

Several researches around the world have studied the use of reclaimed water in concrete, with various levels of success. The reuse of recycled water from the recycling of unset/discarded concrete as mixing water for concrete is common practice in almost all ready-mixed concrete plants in Germany. The disposal of such wastewater is no longer being environmentally accepted. The recycled water consists primarily of the mixture of water, cement, and fines that remain after removal of the aggregate, but it also includes the wash water used for washing and cleaning the returning mixer trucks, concrete pumps, and other equipment, as well as the precipitation water collected on the production areas. The feasibility of using reclaimed wastewater in concrete mixtures has also been studied in Indonesia. The reclaimed wastewater is lower in quality than potable water. Researchers have also shown that concrete with improved initial compressive strength could be made with reclaimed wastewater used partially or totally in lieu of the mixing water.

The use of potable and treated waters was also tested in Saudi Arabia, and setting time and compressive strength were evaluated for the concrete. Pore solutions extracted from the mortar specimens were analyzed for alkalinity and chloride content. Results showed that the treated water tested in this study qualifies to be used in making concrete. The suitability of using treated wastewater for mixing concrete was evaluated in Kuwait. Concrete cube specimens were cast using tap water, preliminary treated wastewater, secondary treated wastewater, and tertiary treated wastewater obtained from the local wastewater treatment plant. It was found that the type of water used for mixing did not affect concrete slump and density. However, setting times were found to increase with deteriorating water quality. In addition, Concrete made with water from the primary and secondary treatment showed lower strengths for ages up to the age of one year and the possibility of steel corrosion increased too. Overall, tertiary treated wastewater was found to be suitable for mixing concrete without adverse effects. Al-Ghusain *et.al.,* 2003, also reported that treated wastewater was not shown to have an adverse effect on concrete. On the other hand, raw sewage reduced the 3 and 28-day compressive strength by 9%. The results (setting time, and mortar and concrete strength tests) showed that biologically treated average domestic sewage is similar from distilled water when used as mixing water. In Malaysia, researchers carried out two tests to determine the feasibility of using treated effluent for concrete mixing. Their results showed that treated effluent increases the compressive strength and setting time when compared with potable water and that treated effluent could be used as mixing water in concrete. EPA has presented suggested guidelines for water reuse. Three configuration alternatives for water reuse systems are presented. One of the sources is the effluent generated by domestic wastewater treatment facilities (WWTFs). The configurations are: (a) Central Treatment near Reuse site(s); (b) the reclamation of portion of wastewater flow; and, (3) reclamation of a portion of the effluent. Treated municipal wastewater represents a significant potential source of reclaimed water for beneficial reuse, for a myriad of purposes, including the concrete industry.

As a result of The Federal Water Pollution Control Act Amendments of 1972, the Clean Water Act of 1977, and its subsequent amendments, centralized wastewater treatment has become commonplace in urban areas of the U.S. Within the U.S., the population generates an estimated about 1.8 million m^3/s (41 trillion gpd) of potential reclaimed water. Of course, reclaimed wastewater might need further treatment in order to guarantee the safety of the users, since raw sewage contains viruses and pathogenic bacteria. Important factors to be considered during this first stage of reuse planning are the: level of treatment (effluent quality), effluent quantity, industrial wastewater contribution to flow (level of inorganic material), system reliability, and the possible need of supplemental facilities (e.g., storage, pumping, and transmission). Overall, it was found that concretes made with recycled water are durable and exhibit the similar properties as concretes made with drinking water or fresh water.

The Indian Environmental Building Guidelines (2010) recommends that the treated water can be used for construction purposes if it meets the Bureau of Indian Standards (BIS) standards. According to the Water Quality Standards for Construction Purposes (456:2000), For construction activities in India, in the water for mixing, the following must be ensured: pH not less than 6; general Total Dissolved Solids (TDS) not exceeding 3200 mg/l; organic TDS, 200 mg/l; inorganic TDS, 3000 mg/l; sulphate, 400 mg/l; chloride, 2000 mg/l; hardness, 440 mg/l; acidity, 50 mg/l; and alkalinity 250 mg/l.

The main objective of this paper is to study the physico-chemical characteristics of wastewater effluents as it affects the reuse in concrete works. The scope of the study is restricted to plain concrete without reinforcements. It is equally limited to selected wastewater samples from Udupi District of Karnataka State, India.

MATERIALS AND METHODOLOGY

Materials

(i) Cement: in this investigation Ordinary Portland Cement of 53 grade with specific gravity 3.15 cement was used.

(ii) Fine aggregate: this consisted of locally available river sand which is free from impurities, the size of which is less than 4.75 mm with specific gravity of 2.64 and absorption capacity of 1%.

(iii) Coarse aggregate: the coarse aggregate used is 20mm in size, crushed angular shape and made it free from dust. The specific gravity of the coarse aggregates of 2.64, absorption value of 0.5% has been used.

(iv) Water samples: the samples include potable water (PW) and 3 treated effluents (TE).

The potable water sample was obtained from the NMAM IT Nitte Campus Central Reservoir. One of the TEs was also from the Wastewater Treatment Plant (WTP) of NMAM IT while the rest were sourced from Abharan motors Service Station (Garage), Karkala and KMF Factory Dairy water, Vamanjoor.

(b) Tests on materials

(i) Specific gravity test: Specific gravity of the materials helps in the concrete mix design and in the calculation of comprising factor in connection with workability measurements. A clean and dry Pycnometer with its cap was weighed (W1), about 1/3 of pycnometer was filled with aggregates and the weight (W2) is determined. The pycnometer was then filled with water including the sample and all air bubbles were removed. The weight (W3) was thus determined. The sample was removed and the pycnometer was filled completely with water and weighed (W4) was determined.

Calculation:

$$\text{Specific Gravity} = \frac{(W2 - W1)}{(W4-W1) - (W3-W2)} \qquad \mathbf{1}$$

where,
W1 – weight of pycnometer in grams.
W2 – weight of pycnometer + sample in grams.
W3 – weight of pycnometer + sample + water in grams.
W4 – weight of pycnometer +water in grams.

(ii) Water Absorption Test: performed to determine water absorption of aggregates. A clean and dry empty container (W1) was weighed. The sample was put in the container and weighed along with its lid (W2). With the lid removed, the container was placed in the oven and dry for 18 hours at a controlled temperature of 105^0C.

After drying, the container was removed with the lid replaced and cooled the in the desiccators and the weight (W3) obtained.

Calculation:

Water absorption w

$$= \frac{(W1-W2)}{(W2 - W3)} \times 100 \qquad \textbf{\textit{2}}$$

(iii) Sieve Analysis for Fine Aggregates:
Sand was used after sieving through 4.75mm and sand confirming to zone was used after sieve analysis. The concrete aggregates was free from impurities and deleterious substances which were likely to interfere with the process of hydration, prevention of effective bond between the aggregates and matrix. The impurities sometimes reduce the durability of the aggregate. Generally, the fine aggregate obtained from natural sources is likely to contain organic impurities in the form of silt and clay.

(c) Preparation of concrete mix

Nominal mix

a. Proportion of concrete [M20]: 1:1.5:3
b. No of moulds: 9 No's per each batch
c. W/C ratio: 0.45
d. Type of cement: OPC 53 Grade

Calculations:

Volume of 1 mould = 0.15 × 0.15 × 0.15
= 0.003375 m^3

Total Qty of dry materials = 50% more than volume of mould
= ({[50/100] × [100/100]} × 0.003375)
= 0.00506 m^3
Qty of cement required = 0.00506/ (1+1.5+3)
= 0.00092 m^3
Qty of cement = 0.00092 × 30 [1 m^3 = 30 bags]
= 0.0276 bags
Qty/wt of cement = 0.0276 × 50 [1 bag = 50 kg]
= 1.38 kg
Qty of fine aggregate = 1.38 × 1.5 = 2.07 kg
Qty of coarse aggregate = 1.38 × 3 = 4.14 kg
Qty of water = 0.45 × 1.38 = 0.621 liters

For 9 moulds

Cement = 9 × 1.38 = 12.42 kg
Fine agg = 9 × 2.07 = 18.63 kg
Coarse agg = 9 × 4.14 = 37.26 kg
Water = 0.45 × 12.42 = 5.589 liters

Mix Design

a. Grade Designation : M20
b. Type of cement : OPC 53 Grade
c. Maximum nominal size of aggregate : 20 MM
d. Minimum cement content : 320 kg/m^3
e. Minimum water cement ratio: 0.45

Specific Gravity of cement: 3.15
Specific Gravity of coarse aggregate: 2.74; fine aggregate: 2.74

Water Absorption coarse aggregate: 0.5 %
Fine Aggregate: 1.0 %

Calculations:

Target Strength for Mix Proportioning

$f_{ck} = f_{ck} + 1.65 \times S$ *(Table 1 of IS: 10262-2009)* ***3***
= 20 + (1.65×4) *standard deviation S = 4 N/mm³* = 26.6 N/mm2

Selection of Water Cement Ratio
From Table 5 of IS: 456-2000, maximum water-cement ratio = 0.50

Selection of Water Content
From Table 2 of IS: 10262-2009, maximum water content for 20 mm aggregate = 186 litre *(For 25 to 50 mm slump range)*

Calculation of Cement Content
Water-cement ratio = 0.45
Cement content = 186/0.45 = 413.33 kg/ m^3

From Table 5 of IS: 456-2000, Minimum cement for extreme exposure condition = 320 kg/m3
413.33 kg/ m^3> 320 kg/ m^3, hence ok

Proportion of Volume of Coarse Aggregate and Fine Aggregate Content
From Table 3 of IS: 10262-2009, Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.5 to 0.62.

Here the water-cement ratio is 0.45; Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lowered by 0.01, the proportion of volume of coarse aggregate is increased by 0.02. Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.45 = 0.61. For pump able concrete these values should be reduced by 10 percent.

Therefore,
Volume of Coarse Aggregate=0.61
Volume of fine aggregate content
= 1-0.61 = 0.39

Mix Calculations

The mix calculations per unit volume of concrete are as follows:

(a) Volume of concrete = 1 m^3

(b) Volume of cement =

$$\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times (1/1000) \quad \textbf{4}$$

$$= \frac{413.33}{3.15} \times (1/1000) = 0.1312\ m^3$$

(c) Volume of water =

$$\frac{\text{Mass of water}}{\text{Specific gravity of water}} \times (1/1000) \quad \textbf{5}$$

$$= \frac{186}{1.0} \times (1/1000) = 0.186\ m^3$$

(d) Volume of all aggregate (e) = [a-(b + c)] ***6***

= [1-(0.1312 + 0.186)]

= 0.6828 m^3

(e) Mass of coarse aggregate = e× Volume of coarse aggregates ×S.G of coarse aggregates ×1000 ***7***

= 0.6828×0.61×2.74×1000

= 1141.23 kg/ m^3

(f) Mass of fine aggregate = e× Volume of fine aggregates ×S.G of fine aggregates×1000 ***8***

= 0.6828×0.39×2.74×1000

= 729.64 kg/m3

Water Adjustments

Coarse Aggregate = 1141.23 kg/ m^3

Fine Aggregate = 729.64 kg/ m^3

Water Absorption by weight of Coarse aggregate = (0.5/100) × 1141.23 = 5.7

Water Absorption by weight of Fine aggregate = (1.0/100) × 729.64 = 8.96 kg

Water Adjustment for the 1m^3 of concrete = Initial water + absorption ***9***

= 186 + (5.7+8.96) = 200.66 kg/ m^3

Mix Proportion

(a) Cement = 413 kg/ m^3

(b) Fine aggregate = 722 kg/ m^3

(c) Coarse aggregate = 1136 kg/ m^3

(d) Water = 201 kg/ m^3

(e) Water-cement ratio = 0.485

Therefore, mix proportion for M20 Grade concrete is 1:1.748:2.747

(d) Analysis of Treated effluents

The collected wastewater samples were mixed together and chemical analysis was carried out. Four water samples (as shown in Figure 1), including controlled potable (tap) water were analyzed for pH, total dissolved solids (TDS), chloride, hardness, alkalinity, and sulfates using the Bureau of Indian Standards and American Public Health Association (APHA, 1998)'s Standards. In all, 16 samples were analyzed for the selected types of water and waste water. The test results were compared with the standard limits.

(e) Experimental investigations on various water types

Study of Slump and Compressive strength of Concrete

For slump, 1:1.5:3 (cement: sand: coarse aggregate) ratio was used by weigh batching with varying water cement ratio. For compressive strength test of concrete cubes, standard cubical moulds of size 150mmx150mmx150mm were used in line with the specifications i.e w/c ratio of 0.45. Nine sets of cubes were prepared for each trial by mixing with fresh water, treated water, garage water and Dairy water respectively and tested for 3, 7 and 28 days of curing with different water types (Figures 2 and 3). The following sixteen combinations were made in achieving various compressive strengths of the concrete:

(1) Fresh water casting (FWC) with Fresh water curing (FWC)
(2) Fresh water casting (FWC) with Garage water curing(GWC)
(3) Fresh water casting (FWC) with Treated water curing (TWC)
(4) Fresh water casting (FWC) with Dairy water curing (DWC)
(5) Garage water casting (GWC) with Fresh water curing (FWC)
(6) Garage water casting (GWC) with Garage water curing (GWC)
(7) Garage water casting (GWC) with Treated water curing (TWC)
(8) Garage water casting (GWC) with Dairy water curing (DWC)
(9) Treated water casting (TWC) with Fresh water curing (FWC)
(10) Treated water casting (TWC) with Garage water curing (GWC)
(11) Treated water casting (TWC) with Treated water curing (TWC)
(12) Treated water casting (TWC) with Dairy water curing (DWC)
(13) Dairy water casting (DWC) with Fresh water curing (FWC)
(14) Dairy water casting (DWC) with Garage water curing (GWC)
(15) Dairy water casting (DWC) with Treated water curing (TWC)
(16) Dairy water casting (DWC) with Dairy water curing (DWC)

RESULTS AND DISCUSSIONS

(a) Tests on waste water types compared with effluents dischargeable into water bodies

The results of the tests on wastewater as compared with both the United States EPA and European Union Standards for effluent dischargeable into water bodies were as presented in Table I. It was observed that the pH of all the samples fell within the standards with the auto-service effluent being the most acidic probably due to the contaminants from automobile battery. The same sample had the highest dissolved solids/salts, even though all the samples are polluted as far as the standards are concerned. The suspended solids were least in the dairy effluent sample with a value of 120mg/l, also constituting pollution. The 4 samples did not pose nitrate pollution threat as their values were all within the recommended safe nitrate values. Both the auto-service and dairy water were found to be more turbid than the prescribed values unlike the fresh water and the wastewater treatment plant effluents which possessed safe turbidity status. The treated wastewater is the only sample constituting chloride pollution, about 1 ½ the standards prescription. This may be due to high level of chloride from the domestic wastewater constituting it. Dairy effluent is the most concentrated with respect to sulphate values, while the least in this regard being the fresh water. It is however noted that none of the samples constitute sulphate pollution. The general pollution order observed was: Fresh water < Treatment Plant Effluent < Dairy water < Auto-Service effluent.

(b) Comparison of various effluents with BIS permissible limits for Construction purposes

The comparison of the various samples with the Bureau of Indian Standards (BIS) permissible limits for construction purposes is as presented in Table II. For all the parameter measured, the results are within the permissible limits provided by the IS: 456(2000) for construction activities.

(c) Results of compressive strengths of concrete with the selected wastewater samples

The results of compressive strengths of the concrete cube castings with the selected samples (nominal mix) are presented in Table III while those with the mix design are shown on Table IV. The measured compressive strengths were found to increase with the curing age in both the nominal mix and the mix design. After the 28 days curing, in the nominal mix the highest compressive strength of 53.77 N/mm^2 was observed in the concrete both cast and cured with dairy wastewater. The least strength of 49.33 N/mm^2 was noted in the ones cast by dairy wastewater but cured by both fresh water and auto-service wastewater. The final compressive strengths recorded in the concrete for mix design were lower in comparison with those of nominal mix. The highest strength of 44.89 N/mm^2 was however noted in the cubes cast with dairy wastewater but cured with fresh water. Thus it was established that the dairy wastewater with relatively high values of physico-chemical properties produced stronger concrete.

CONCLUSION

This study concluded that the use of treated effluents, auto-service stations (garage) water and dairy wastewater has no noticeable side effect on the strength of concrete produced from them. The compressive strength of the plain concrete cast and cured with reused wastewater effluent increased with the curing period and the physico-chemical properties. The replacement of fresh water by treated effluent conserved the natural water resources and increased the strength of concrete. The study therefore recommends the reuse of treated effluents with acceptable physico-chemical properties for use in plain concrete works. Further investigations should be carried out on the effects of effluents on the durability of both plain and reinforced concrete structures.

References

Ainul H. N, Bala M., Mohammad I., Zaiton Abdul-Majid (2012). “Characteristics of treated effluents and their potential applications for producing concrete”. Journal of Environmental Management 110: 27-32.

Al-Ghusain, I. and Terro, M. J (2003). “Use of treated wastewater for concrete mixing in Kuwait.” Journal of Science and Engineering, 1:30.

APHA (1998) “Standard Methods for the Examination of Water and Wastewater”, 15th Edition, American Public Health Association, New York.

Indian Standard (2009) IS 10262-2009 Recommended Guidelines for Concrete Mix Design.

Indian Standard (2000) IS 456-2000 Plain Reinforced Concrete – Code of Practice.

Lobo, C and Mullings, G. M (2003) ‘Recycled Water in Ready Mixed Concrete Operations’. Concrete in FOCUS (Reprinted by permission of National Ready Mixed Concrete Association) 2: 17–26.

Neville, A.M (1997). “Properties of Concrete”, Longman, England 4: 734.

Neville A.M. (1981). “Properties of Concrete”, Pitman Books Limited, London.

Ojoawo, S.O and Oladejo, A.M (2013). An investigation into the effects of water contaminated with chloride salts on the compressive strength of concrete. Proceedings of 2nd International Conference on Engineering and Technology Research, FET Conference 2013, LAUTECH, Ogbomoso, Nigeria (March 2013), 2: 1-10. ISBN: 978-2902-58-6.

Ooi S. L., Mohd, R. S, Mohammad, I and Imtiaj, A (2001). “Reusing of treated effluent in concrete technology”.Journal of Technology 34: 1 – 10.

Shetty, M.S (2005) “Concrete Technology Theory & Practice”, Published by S.Chand & Company, Ramnagar, New Dehli.

Steinour, H. H (1960), ‘Concrete Mix Water – How Impure Can it Be?’ Portland Cement Association Journal Research and Development Laboratories, 3: 32– 50.

US EPA (2010) Nine articles promulgated by EPA Order Huan-Shu-Shui-Tze No. 0990112348F on December 15, 2010.

Fig 1: Treated Waste Water Effluents

Fig 2: Curing process of fresh water

Fig 3: Curing process of waste water

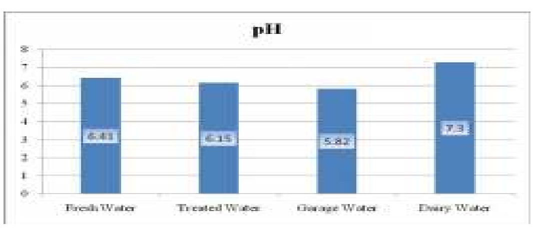

Fig 4: Comparison of pH value

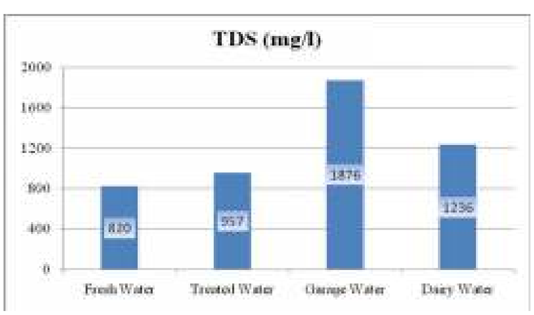

Fig 5: Comparison of Total dissolved solids

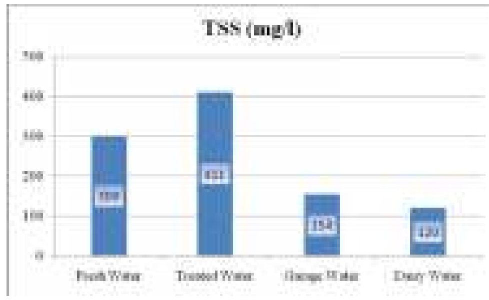

Fig 6: Comparison of Total suspended solids

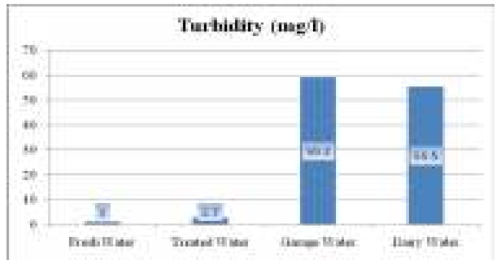

Fig 7: Comparison of Turbidity

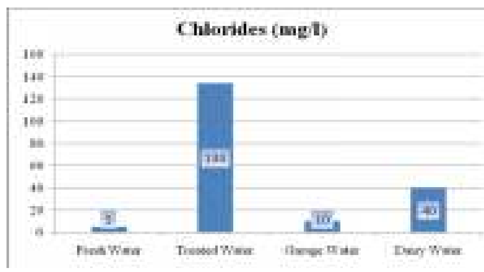

Fig 8: Comparison of Chlorides

Fig 9: Comparison of Total Hardness

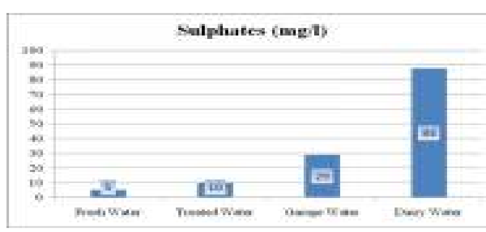

Fig 10: Comparison of Sulphates

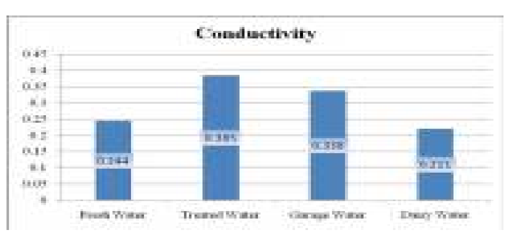

Fig 11: Comparison of Conductivity

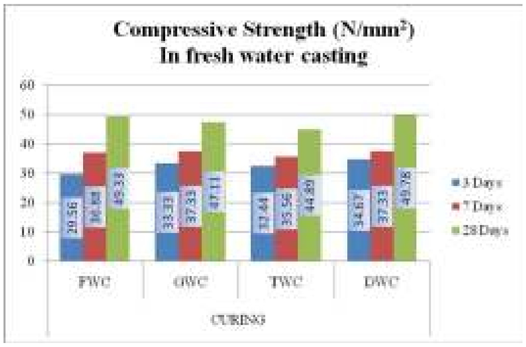

Fig12: Concrete Compressive strength in FWC

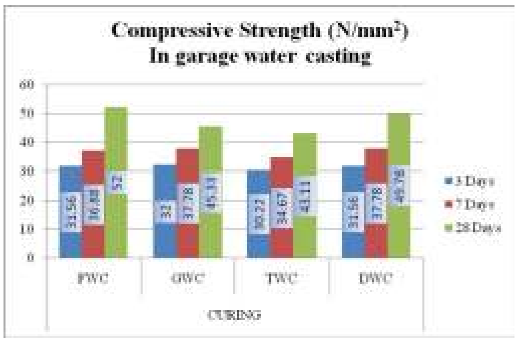

Fig 13: Concrete Compressive strength in GWC

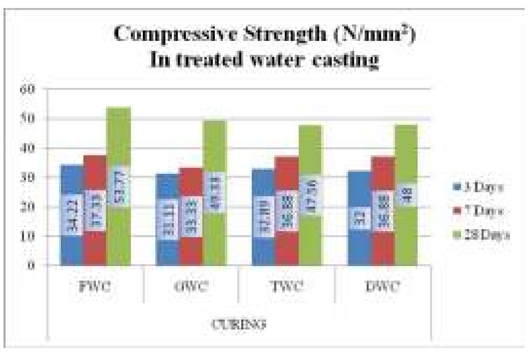

Fig 14: Concrete Compressive strength in TWC

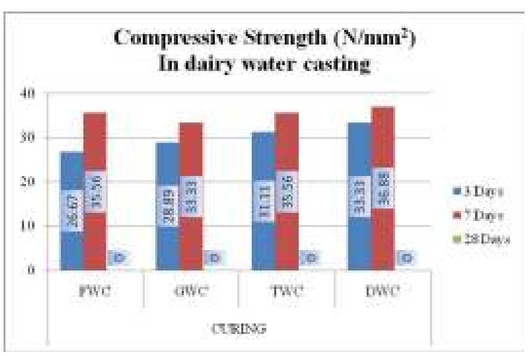

Fig 15: Concrete Compressive strength in DWC

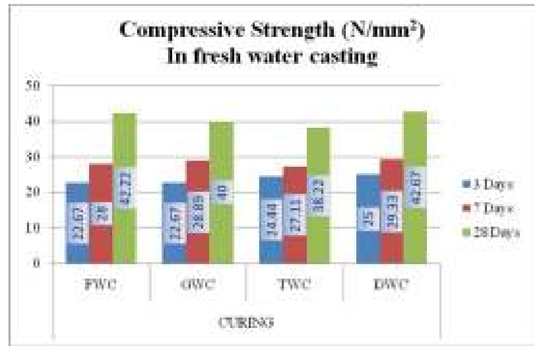

Fig 16: Concrete Compressive strength in FWC

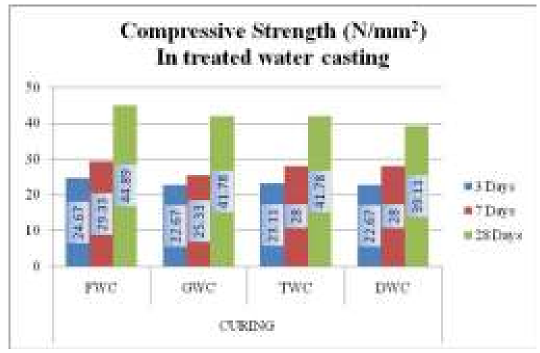

Fig 17: Concrete Compressive strength in TWC

Table I: Wastewater Quality parameters

Parameters	*Fresh water*	*Garage water*	*Treated water*	*Dairy water*	*EPA/E.U Effluent Standard*
pH	6.41	5.82	6.15	7.3	6.0 – 9.0
TDS (mg/l)	820	1876	957	1236	30
TSS (mg/l)	300	154	411	120	100
Nitrates (mg/l)	NA	1.5	NA	1.1	50
Turbidity (NTU)	1	59.2	2.7	55.5	< 50
Chlorides (mg/l)	5	10	134	40	100
Total hardness (mg/l)	288	300	104	10	N/A
Sulphates (mg/l)	5	29	10	88	250
Conductivity (μS)	0.244	0.338	0.385	0.221	N/A

Table II: Comparison of various effluents with BIS permissiblelimits (Construction purpose)

Parameter	*Fresh water*	*Garage Effluent*	*Treated Effluent*	*Dairy Effluent*	*Construction activity IS: 456(2000)*
Total Hardness (mg/l)	288	10	104	300	440mg/l
TDS (mg/l)	820	1876	257	1236	3200 mg/l
Sulphates (mg/l)	5	29	10	88	400 mg/l
Chlorides (forPCC) (mg/l)	5	5	134	40	200 mg/l
pH	6.41	5.82	6.15	7.3	Not less than 6

Table III: Compressive strength of concrete for Nominal

CASTING	*DAYS*	*CURING*			
		FWC	*GWC*	*TWC*	*DWC*
FWC	3	29.56	33.33	32.44	34.67
	7	36.88	37.33	35.56	37.33
	28	49.33	47.11	44.89	49.78
GWC	3	31.56	32.00	30.22	31.56
	7	36.88	37.78	34.67	37.78
	28	52.00	45.33	43.11	49.78
TWC	3	34.22	31.11	32.89	32.00
	7	37.33	33.33	36.88	36.88
	28	53.77	49.33	47.56	48.00
DWC	3	26.67	28.89	31.11	33.33
	7	35.56	33.33	35.56	36.88
	28	49.33	49.33	52.00	53.77

Table IV: Compressive strength of concrete for Mix Design

CASTING	*DAYS*	*CURING*			
		FWC	*GWC*	*TWC*	*DWC*
FWC	3	22.67	22.67	24.44	25.00
	7	28.00	28.89	27.11	29.33
	28	42.22	40.00	38.22	42.67
GWC	3	24.67	22.67	23.11	22.67
	7	29.33	25.33	28.00	28.00
	28	44.89	41.78	41.78	39.11