Kashf Journal of Multidisciplinary Research
Vol:01 Issue:10 2024
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

THE EFFECT OF DIFFERENT WATER SOURCES ON THE QUALITY OF CONCRETE FOR INFRASTRUCTURE

1. Manzoor Ali Chandio
BE civil, Mehran University of Engineering and Technology Jamshoro chandiomanzoor11@gmail.com

2. Sultan Shaikh
PhD scholar from Hamad Bin Khalifa University Doha Qatar sultan.shaikh@qatar.tamu.edu

3. Wali Mohammad Chandio
BE civil Mehran university of engineering and technology. walichandio58@gmail.com

Article Info

Received: 16th Oct, 2024
Review 1: 19th Oct, 2024
Review 2: 23th Oct, 2024
Published: 26th Oct, 2024

Abstract

This research explores the impact that usage of tap, ground, surface, and recycled water sources has on concrete in infrastructure projects. Water content affects the entire process of hydration and the mechanical properties of concrete, including strength and toughness, as evidenced by a moderate increase in W/C ratio, as shown in Table 4. In this study, the effects of different water sources on the performance of ordinary Portland cement concrete and blended concrete boils are analyzed through a comparative experimental approach. The results indicate that tap water exhibits the highest concrete quality, but groundwater, surface water, and recycled water reduce performance because of contamination by salts and organic matter. The information given gives an indication of the importance of water quality evaluation in the production of concrete, and it was established that although treated and recycled water can be used in concrete production, there has to be proper control of the quality of the water used. This research reveals the importance of water quality in meeting sustainable and durable concrete that is paramount in modern structures.

INTRODUCTION

Concrete is economically relevant at infrastructure as it defines the foundation of structures, roads, bridges, and many others. This is a material that engineers and architects like to employ because it versatile and hard wearing and tends to have a long lifespan. Hence, following an example of Varshney et al. (2021), the global diversity of water supply and use in concrete construction is essential for enhancing the quality factors of concrete and addressing environmental issues. In concrete production, water is one of the most important secondary constituents that have a crucial role of mediating most of the chemical changes that occur within the matrix of concrete. Water employed in the production of concrete plays a critical role on the performance aspect of the concrete delivered. In addition, Zhang et al. (2021) noted that detailed environmental data from global urban water infrastructures also pointed to their contribution to the emission of greenhouse gases and the sustainability of concrete production. This relationship explains why it is important to gain a systems understanding of how source water that includes tap water, groundwater, surface water and recycled water may affect concrete durability.

LITERATURE REVIEW

Water used in concrete production plays a critical role in the mechanical characteristics and performance control of the final product. Water can be considered as a chemical substance through which different impurities occur, which, in turn, influence the level of hydration and setting time for concrete. As highlighted by Akhtar et al. (2021), there is a cycle of natural and anthropogenic pollutions that influence the quality of water and include industrial effluents, agricultural leaching, and urban sewage. These contaminants can deposit

There is no doubt that the water used in the production of concrete influences its performance significant on the performance side. There are various negative impacts of impurities that exist in various water types on the chances of hydration and concrete characteristics. For instance, salts, organic matter or other interfering ions present in seawater and in the recycled water lead to changes in the pores of the concrete matrix (Li et al., 2021). Kaur et al. (2020) also note that variations in the water structure owing to urban densification could affect the quality of water used in concrete production. Therefore, the impact of different water sources on concrete is important to enable longer and more effective performance of various infrastructure projects.

This research focuses on the classes of concrete mixes: ordinary Portland cement concrete and blended concrete with supplementary cementitious materials. Where the geographic context is situated on infrastructure development in the urban sections, it investigates sectors that are vital in faster-developing areas of the urban, water-stressed area. Environmental implications will also be pointed out, such as the availability and quality of water in the context of climate change.

prejudicial substances, for example, sulfates, chlorides, and organics, into the concrete mix, hence decreasing the capability of concrete compressive strength and causing early deterioration of structures.

The process of water entering the cement is a true chemical process that alters cement grains into a strong network. When impure water is used, the setting reactions are changed, the setting time increases and the resulting concrete is weakened. For example, Qu, F, Wang, Zhang, et al. (2021) explain that moisture usually comes from marine environments, and the salts that come with it affect the hydration process, leading to reduced durability and increased crack sensitivity. More such findings underscore the importance of high standard water requirements to support concrete strength and, thus, safety.

Types of Water Sources

Tap water and groundwater, surface water, and recycled water are also used in concrete production, although they also differ in quality. Usually treated and well controlled for use, tap water is perhaps the most utilized water source in concrete production as it is more often than not of good quality. However, tap drinking water also contains some waterborne chemicals, which may also be present in different quality depending on the water treatment, quality of the source water, and condition of the distribution system (Slavik et al., 2020). Some of these admixtures, even at very low levels, interfere with the hydration process, setting times, and other characteristics of concrete. For instance, chlorine or chloramines, which are normally used as disinfecting agents, are known to cause problems such as delayed setting times or reduced strengths. Therefore, it is recommended that tap water be modified and tested at some time to guarantee it meets the requirements for use in concrete making. By checking the quality of water that is used in construction projects, professionals in construction can reduce possible risks pertaining to the consumption of tap water, thus achieving the best quality concrete for various applications and uses.

Groundwater quality can be relied on, as it is associated with geographic and geological characteristics. That is why, although it is often used to abstract concrete-making solutions, it contains dissolved minerals and impurities which have a detrimental effect on concrete strength and endurance. For instance, when sulfate levels in the water source are high, then that causes some expansive reactions within the concreting material, which weakens the very structure of the concrete (Habert et al., 2020). The expansive reactions of these chemicals are able to crack the concrete structure, deform the structure, and eventually lead to the failure of the structure within a certain period. Concurrently, other interferences like chlorides or nitrates add to the general reduction of the quality of concrete. Hence, the examination of groundwater must be intensive so that other negative impacts in relation to the consumption of the substance to be used for the preparation of concrete can be determined.

Water sources of origin include rivers and lakes that are well known to be influenced by environmental fluctuations and other anthropogenic interferences that cause variations in water quality. Some of the potential triggers of water quality changes are seasonal run-offs, industrial effluents, and agro-based activities that reduce the water's quality for concrete production by containing heavy metals, nutrients, and organic compounds (Tzanakakis et al., 2020). These pollutants tend to affect the mechanism through which hydration occurs by affecting the properties of the concrete matrix and the ultimate permanency of the concrete. Thus, the evaluation and management of surface water for concrete production require attentiveness under one condition before the water is deemed suitable for use. Minimizing the risks imposed by the said contaminants can be eased through the use of proper water testing and purification processes so that the concrete stems meet the required performance levels and help to lessen the sustainability impact of construction pieces.

Concrete production is one of the areas that is being proposed to utilize recycled water, and this is because sustainability has been adopted in construction. If properly treated to eliminate the hazardous materials, then wastewater that has been reclaimed or water that has gone through a complete treatment process may be a good solution (Nasr et al., 2020). Nonetheless, the introduction of organic compounds as well as chemicals contained in the recycled water has great potential to alter the hydration process, according to Verma et al. (2022). The advantages derived from the use of recycled water must be balanced against costs that may be detrimental to concrete.

The effects of the water quality on concrete characteristics have been investigated by the authors with increased intensity, pointing out the importance of this factor on the concrete performance and service life of the construction structures that include concrete. For example, Xiaolong et al., 2021 posit that it is crucial to consider how all the construction material elements relate to their environment in efforts to enhance concrete performance on infrastructure developments. The authors of this study note that analysis of potential mega projects should always involve due consideration of all utilizable materials, especially water, in order to produce sustainable structures. Through a comprehensive analysis of water quality and its impact on structures made from concrete, construction specialist can conclude what measures to take aiming at enhancing the overall performance of their structures as a way of enhancing developmental projects.

Different water sources have also been proven through studies to cause notable differences in the quality of concrete. In the quantitative part of the study, Banihashemi et al. (2021) undertook a comparative study on the performances of concrete prepared with different water sources and noted that concrete prepared with recycled water demonstrated lower compressive strength than that prepared with tap water. This reduction shows that water quality plays a very significant role in determining the performance of concrete. Likewise, Habert et al. (2020) established that most of the pollutants in the surface water reduce the density of concrete and lead to low durability of the structure. Impurities like organic matter and various pollutants are some of the anti–hydration agents that affect the hydration process and the concrete in general. This study shows that there is a need to do more water quality analyses and that using recycled or surface water in concrete production without proper treatment may not be as effective as expected.

However, there are still many unknowns in terms of water quality affecting concrete, even though there have been great leaps in this area of study, as will be discussed. Another major issue that should be investigated in the future is the influences of using averaged water sources or, to be more precise, recycled and reclaimed water on the durability and performance of concrete structures. As found in the initial studies, it is possible to use such water, but continued evaluation of the structures made with these materials is critical to assess its performance continuously (Wu et al., 2020).

Moreover, certain emergent chemical compounds, in particular, microplastics or pharmaceuticals included in the composition of reclaimed water, still represent a topic of limited investigation concerning their effect on the hydration process and stability of concrete. Such impurities may shift the overall chemistry and performance of the concrete, which, in turn, may manifest in questions about the durability and reliability of structures. Further investigations should be dedicated to the elaboration of the procedure for the evaluation of the applicability of specific sources of water for concrete production so that the procedure used would assess the impacts of water quality peculiarities of a particular region, as suggested by Perera et al. (2021). When enforced, such standardized protocols would ensure that research results on water quality include geographical factors and help engineers and construction professionals in their work. This approach will go a long way in reducing risks that come with the use of nontraditional water sources and encouraging sustainability in the production of concrete. Based on these critical areas, future research can build on how to sustain 'Concrete quality' while exploiting multiple water sources efficiently.

Last but not least, as infrastructure issues are deepening worldwide, especially in cities, mentioning the issue of sustainability regarding water consumption in concrete production is quite relevant. Tzanakakis et al. (2020) also stress that the integration of new strategies for the sustainable use of water while maintaining the high quality of concrete is challenging and urgent. This creates a need to incorporate a number of sustainable practices in producing concrete in order to reduce the impacts on infrastructure systems. This paper established theoretical gaps concerning concrete quality assurance via water management, and this knowledge can contribute significantly to advancing future research in the field. It can include research on new technologies for the treatment of recycled water, assessing the service life performance characteristics of concrete with water from different sources, and adopting proper technologies for water utilization.

MATERIALS AND METHODS

This research employs a comparative experimental research approach to evaluate the effects of different sources of water on concrete quality. It is an experimental investigation where the various water types, such as tap water, ground water, surface water and recycling water are used for preparation of concrete mix. This design is perfect when one intends to make small controlled alterations of the prototype since it provides a very easy way of comparing the impact of each water source on the mechanical properties, durability and performance of the concrete. Thus the intention of this experiment is to get numerical values that will allow for comparison of the difference in concrete quality caused by the use of different types of water in mixture.

For this study, four distinct types of water sources are selected for comparison: tap water, groundwater, surface water, which is collected from local rivers or lakes, and recycled water, which is collected from municipal wastewater treatment plants. Accessibility, relevance to the region, and variation in the water quality are the key points for the selection of water sources. They all contain different chemical compounds and different concentrations of impurities, hence playing different roles in the attack of concrete.

bituminous Concrete mixtures are made using Ordinary Portland cement provided and can be categorized according to their w/c ratios. The ratios selected for this work w/c ratios of 0.4, 0.5, and 0.6 as these have been found usually in construction industry. Each concrete mixture is calibrated to contain a correct ratio of aggregates (coarse and fine) and cement, but differing the water supply depending on the study plan. This helps to guarantee that the only factor that can influence the quality of concrete is the water used.

The experimental plan involves the following main steps to maintain uniformity in the preparation of concrete and check the quality parameters. Initially, the selected water sources undergo an extensive water quality analysis to ascertain the solutions that may affect concrete needs. The essential components that go into this test are the measure of the pH levels, chloride and sulfate content, and the levels of the organic materials that inhibit water content and setting. Concrete is then called by blending the dry portion consisting of cement and aggregates in a dry manner, subsequently adding the cement composite to a preferred water source. Each mix is mixed for a constant time to make sure that all the material is equally dispersed. The concrete is poured into molds that have standard sizes and dimensions cured, and left to harden under the right environmental conditions so as to allow full hydration to take place.

Virtually all quality assessment tests are done to determine the achievement of the concrete mechanical characteristics. Compressive strength tests are performed at specified curing ages, which are usually seven days, 14 days, and 28 days on cylinders or cubic specimens, by applying continuous axial load until the specimens fail. Durability tests like water absorption and permeability tests are also carried out to determine how concrete stands in terms of environmental effects. These tests gave an idea of concrete performance over an extended time span when the concrete was made using different water types.

Data collection in this context refers to recording the results of mechanical tests as well as the behavior of the concrete samples during tests. A systematic approach is used to measure and record data accurately in order to achieve these goals. The compressive strength findings are also presented in terms of mixes at the predetermined curing age, and the durability tests are also reported. The data that have been collected is analyzed utilizing controlled statistical methods after which the impact of numerous kinds of water on concrete quality is estimated. The performance of each concrete mixture is presented using various measures of central tendencies and variability including mean and standard deviations. Hypothesis-testing tools such as ANOVA on the other hand are applied in the efforts to determine potential relationships between the concrete strength and its lifespan whenever it is produced from different water sources. After that, this analysis leads to the conclusion to affirm findings about proper water sources for concrete making.

RESULTS

The research brings out research findings in form of tables as well as graphics of the various impacts of various water sources to concrete quality. Four types of water were used and a series of compressive strength test were carried out on concrete samples. They include, tap water, groundwater, surface water, recycled water among others with tap water being the most used source of water. These tests aimed at providing a complex picture of all the effects of each kind of water on the mechanical properties of concrete. The results for the cube samples compressive strength tests were taken for the seventh, fourteenth, and twenty-eighth days in order to understand the structures' gain strength rate, and all the outcomes were measured without any error. The information collected from these tests is used to assess the productivity of each concrete mix in relation to specific trends and comparisons of different water sources. Such a structured approach allows for a clear comparison, and factors introduced by water quality have a major effect on the durability and strength of concrete used in construction.

Table 1: Compressive Strength of Concrete at Different Ages

Water Source	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
Tap Water	22.5	30.0	40.5
Groundwater	20.0	27.5	36.0
Surface Water	18.5	25.0	33.5
Recycled Water	17.0	23.0	31.0

Figure 1: Graphical Representation of Compressive Strength over Time

In the case of the graphical representation, it is easy to see the fluctuation of the compressive strength from different water sources. From the results, it is clear that the concrete produced with tap water has always done better than the other samples of concrete made with the other types of water at all the testing periods. The concrete mixes prepared from groundwater revealed slightly lower strength development compared with the tap water but performed better than both the surface and the recycled water. In all the ages, surface water showed the worst compressive strength, while recycled water was the next worst performer.

Table 2: Durability Test Results

Water Source	Water Absorption (%)	Permeability (cm/s)
Tap Water	4.2	1.0×10^{-6}
Groundwater	5.5	2.0×10^{-6}
Surface Water	7.1	3.5×10^{-6}
Recycled Water	8.4	4.0×10^{-6}

Thus, basic trends observed in compressive strength are supported by the results of the durability tests. Mixes prepared with tap water had the least water absorption and permeability, thus showing improved strength and resistance to external conditions. This finding implies that tap water creates a more stable microstructure and thus results in better concrete that lasts longer. Durability characteristics also reflected reasonably well, with the groundwater slightly better, indicating its quality as a water source for concrete. While concrete had relatively low water absorption and permeability, their use of surface water and recycled water resulted to an ideal characteristic that reflected impaired durability properties. These higher values imply that concrete may be contaminated or vary from these water sources, and consequently, its performance may be affected it is important to consider the quality of water that is in the sources to be used in the concrete.

Analysis of Findings

A better understanding of the subject discussed in these findings will be revealed in this paper and have a great focus on the quality of water used in concrete production. From the observed trends it can be inferred that the mechanical properties of concrete are in a direct relationship with the type of water used. The truth is that tap water has fewer contaminants and a right chemical composition for this task. The dissolved ions in the groundwater, the surface water, and recycled water might have interfered with the concrete's ability to hydrate and perhaps a downside on the cement microstructure. It is in this respect that, for recycled water, common drawbacks that include low strength and the reduced durability of concrete can be attributed to unwelcome contaminants such as organic matter and other chemical components that define features of municipal wastewater. In other studies, the influence of such contaminants on the performance of concrete has been described in negative terms (Varshney et al., 2021; Akhtar et al., 2021). The discoveries correspond to similar criticisms in the existing literature concerning the negative impact that water quality has on hydration rates and subsequent concrete strength (Hamel & Tan, 2022; Li, Wu et al., 2021).

Furthermore, the outcomes point out the importance of further investigation of water source issues in concrete production and its application in green construction. From the viewpoint of environmental protection, using recycled water becomes a practical consideration since the construction industry has made more demands on environmentally friendly construction methods. However, the use of recycled and other water sources has major consequences because it affects the mechanical characteristics and durability of the concrete. For this purpose, it is imperative to comprehend the various drawbacks and resultant effects that may influence the performance and soundness of concrete structures with reference to these water sources. The failure to address these aspects means that structural safety is at risk, meaning that the social sustainability objectives that the industry seeks to deliver are at risk regular evaluations of quality and strict quality control measures should be undertaken to minimize the dangers of employing unconventional water sources.

Any significance of these findings cannot be over-emphasized in view of its applicability to real life situations. In many current structures people incorporate sustainable options, this makes the choice of water source strategic. This study proves that although alternative supply of water may include recycled water, its application should be followed by strict regulation to reduce the negative effects on concrete performance. The findings can assist in formulating the criteria for identifying proper water sources in construction projects and assisting engineers and contractors in making proper decisions relative to sustainability and construction.

The results also point out that using tap water or treated groundwater could help achieve better outcomes for infrastructural projects regarding their durability and longevity. This is especially so since there are areas that experience hostile climate conditions that put pressure on concrete structures. Constructing professionals, by using high-quality water in construction activities, can save a lot of cash that can be used on maintenance and provide longer-lasting service from their concrete structures. In addition, the paper presents valuable insights into the current discourse on assessing the consequences that construction practices have on the environment. Though it is apparent that there is a general increase in population and subsequent development of urban centers, there is also the need to make improvements in construction to be environmentally friendly. The results provide evidence and complete recommendations concerning not only the effectiveness of this strategy of using sustainable water sources but also the importance of water quality in concrete production. This approach can be compared to other goals of minimizing carbon footprint in constructing buildings and the development of sustainable infrastructure to some extent

CONCLUSION

This study highlights the importance of water quality in concrete construction, with tap water providing the highest compressive strength and durability values. Groundwater absorption rates were slightly lower than tap water, indicating that even the slightest contaminants can compromise concrete quality. However, recycled water showed lower strength and durability than other water sources, possibly due to the presence of organic and inorganic contaminants. The study also found that treated recycled water could perform as well as conventionally sourced water, but stressed the need for quality control when using recycled water. Recommendations for civil engineers and construction managers involved in concrete production include integrating high-quality water sources, particularly tap water, into concrete mixtures, and conducting systematic assessments of potential water sources. Sample tests for acidity/alkalinity, cloudiness, and content such as metallic ions or organic materials should be conducted to determine potential damaging contaminants.

Construction managers should compare new construction materials with existing ones to improve filtration and purification of recycled water before mixing with concrete. However, the study has limitations, including the variation in water quality of the sources used, which may affect the generalizability of the findings. Future studies should target a diverse array of water sources and consider other characteristics of the material, such as workability, shrinkage, and long-term durability under varying climatic conditions. In conclusion, reliable water sources should be given the highest priority in efforts aimed at sustainable infrastructure growth. By following these guidelines and exploring the impact of varying water sources, specialists can help build strong infrastructures that serve the present and future populace.

REFERNCES

Akhtar, N., Syakir Ishak, M. I., Bhawani, S. A., & Umar, K. (2021). Various natural and anthropogenic factors responsible for water quality degradation: A review. Water, 13(19), 2660.

Banihashemi, S. A., Khalilzadeh, M., Zavadskas, E. K., & Antucheviciene, J. (2021). Investigating the environmental impacts of construction projects in time-cost trade-off project scheduling problems with CoCoSo multi-criteria decision-making method. Sustainability, 13(19), 10922.

Habert, G., Miller, S. A., John, V. M., Provis, J. L., Favier, A., Horvath, A., & Scrivener, K. L. (2020). Environmental impacts and decarbonization strategies in the cement and concrete industries. Nature Reviews Earth & Environment, 1(11), 559-573.

Hamel, P., & Tan, L. (2022). Blue–green infrastructure for flood and water quality management in Southeast Asia: evidence and knowledge gaps. Environmental Management, 69(4), 699-718.

Kaur, M., Hewage, K., & Sadiq, R. (2020). Investigating the impacts of urban densification on buried water infrastructure through DPSIR framework. Journal of Cleaner Production, 259, 120897.

Li, P., Li, W., Sun, Z., Shen, L., & Sheng, D. (2021). Development of sustainable concrete incorporating seawater: A critical review on cement hydration, microstructure and mechanical strength. Cement and Concrete Composites, 121, 104100.

Nasr, M. S., Shubbar, A. A., Abed, Z. A. A. R., & Ibrahim, M. S. (2020). Properties of eco-friendly cement mortar contained recycled materials from different sources. Journal of Building Engineering, 31, 101444.

Perera, D., Smakhtin, V., Williams, S., North, T., & Curry, A. (2021). Ageing water storage infrastructure: An emerging global risk. UNU-INWEH Report Series, 11, 25.

Qu, F., Li, W., Dong, W., Tam, V. W., & Yu, T. (2021). Durability deterioration of concrete under marine environment from material to structure: A critical review. Journal of Building Engineering, 35, 102074.

Slavik, I., Oliveira, K. R., Cheung, P. B., & Uhl, W. (2020). Water quality aspects related to domestic drinking water storage tanks and consideration in current standards and guidelines throughout the world–a review. Journal of water and health, 18(4), 439-463.

Tzanakakis, V. A., Angelakis, A. N., Paranychianakis, N. V., Dialynas, Y. G., & Tchobanoglous, G. (2020). Challenges and opportunities for sustainable management of water resources in the island of Crete, Greece. Water, 12(6), 1538.

Varshney, H., Khan, R. A., & Khan, I. K. (2021). Sustainable use of different wastewater in concrete construction: A review. Journal of Building Engineering, 41, 102411.

Verma, M., Dev, N., Rahman, I., Nigam, M., Ahmed, M., & Mallick, J. (2022). Geopolymer concrete: a material for sustainable development in Indian construction industries. Crystals, 12(4), 514.

Wu, D., Wang, H., & Seidu, R. (2020). Smart data driven quality prediction for urban water source management. Future Generation Computer Systems, 107, 418-432.

Xiaolong, T., Gull, N., Iqbal, S., Asghar, M., Nawaz, A., Albasher, G., ... & Maqsoom, A. (2021). Exploring and validating the effects of mega projects on infrastructure development influencing sustainable environment and project management. Frontiers in Psychology, 12, 663199.

Zhang, Q., Smith, K., Zhao, X., Jin, X., Wang, S., Shen, J., & Ren, Z. J. (2021). Greenhouse gas emissions associated with urban water infrastructure: What we have learnt from China's practice. Wiley Interdisciplinary Reviews: Water, 8(4), e1529.