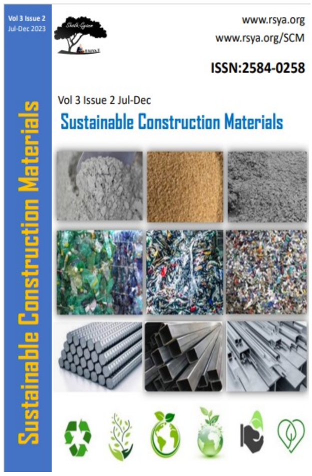

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Analysis of the Application of Non-Potable Water in Concrete

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Abstract: The rise in population has necessitated the quick construction of infrastructure, which in turn demands a substantial quantity of fresh water. The global water crisis is already underway, with over 700 million individuals projected to experience water scarcity by the year 2030, according to UNICEF projections. Under such circumstances, it is imperative to minimise the utilisation of potable water in the construction sector by substituting it with seawater, as well as home and industrial wastewater. This article seeks to provide a concise overview of the use of non-freshwater sources in construction, based on past research. This article examines the impact of sea water and recycled waste water on the mechanical and durability characteristics. It reveals that the high salt content in sea water diminishes the compressive strength, but this can be mitigated by employing admixtures and specialised cements. Furthermore, the utilisation of sea water and recycled waste water in cement concrete necessitates meticulous oversight.

Keywords- *Sea water, domestic waste water, industrial waste water, concrete, compressive strength*

1. INTRODUCTION

India is the world's second most populous country, following China, and it represents around 17.68% of the global population. India possesses several rivers and lakes containing freshwater; yet, these resources are insufficient to meet the needs of the entire population[2]. The first factor is that India is a developing nation and water is utilised for both home and commercial purposes[2]. Meeting the water demands of such a massive population is a challenging endeavour. The increasing population, along with an adverse climatic environment, has a significant effect on the availability of resources, including clean drinking water, which is not accessible in certain places of the world[3]. Given the limited resources and ongoing population growth, it is imperative to refrain from utilising fresh water in industries like building. This will ensure that fresh water can be allocated to meet the drinking needs of the population. The building industry plays a crucial role in the development of infrastructure. The concrete is composed of coarse aggregate, fine aggregate, cement, and water[4], [5]. Water is crucial for the hydration process of cement, where cement acts as a binder in cement concrete[6]. Cement concrete is highly sought after as a construction material due to its exceptional features, including durability, reliability, long service life, and cost-effectiveness[7]. The objective of this study is to examine the different attributes of water and their impact on the properties of cement concrete, based on prior research.

2. LITERATURE SURVEY

This section describes the characteristics of water such sea water, domestic and industrial waste water which cannot be used for drinking purpose without any treatment or purification. In this section, the properties of sea water and waste water has been discussed as well as with their acceptable limits of impurities.

2.1 Sea water

Approximately 96.5% of the Earth's water supply consists of sea water[8]. The flavour of sea water is characterised by its salinity, which is roughly 3.5%[9]. This indicates that there are 35 grammes of salt in every litre of water. Nevertheless, the salinity of seawater varies across different regions of the world[9]. Kaushik et. al. proposed the permissible thresholds for contaminants in seawater based on the weight of water, as presented in table 1.

Table 1. Permissible limits of impurities[10]

Substance	Permissible limit (in %)
Organic substance	0.02
Inorganic substance	0.30
Sulphates in terms of $CaCO_3$	0.04
Chlorides of alkalis in terms of $CaCl_2$	0.2 for Plain concrete 0.05 for RCC

Seawater has a disadvantage in that it alters the engineering characteristics of cement such as permeability and setting time, however the use of various supplemental cementitious materials and natural pozzolans is efficient in reaching the desired effects[3], [10]. As per a study by Mori et. al., the compressive strength of concrete made with sea water will be more or less same as that of standard concrete after a decade [3]. This decrease in strength can be counter by using the pozzolanic material in concrete which will reduce the permeability and porosity of concrete and hence increase the strength of concrete[3]. As per IS 456-2000, the pH of water to be used in the concrete should be limited to 6[11] hence the seea water should be tested for harmful and deleterious substances (as shown in fig. 1) that might induce sulphate attacks, corrosion, and acid attacks, among other things, as a result of the presence of undesired substances in it. The presence of chloride ions in sea water causes efflorescence and corrosion, which are two of the most serious issues that may occur in any building. Until the steel bar is completely corroded, the corrosion will continue to occur. The structure of a building is made up of steel bars embedded in concrete as a source of strength, thus the choice of sea water should be considered carefully. the studies suggested to avoid use of sea water in concrete[12] and as per studies, the decrease in strength vanishes as increase in strength in 10-20 years age of concrete[13].

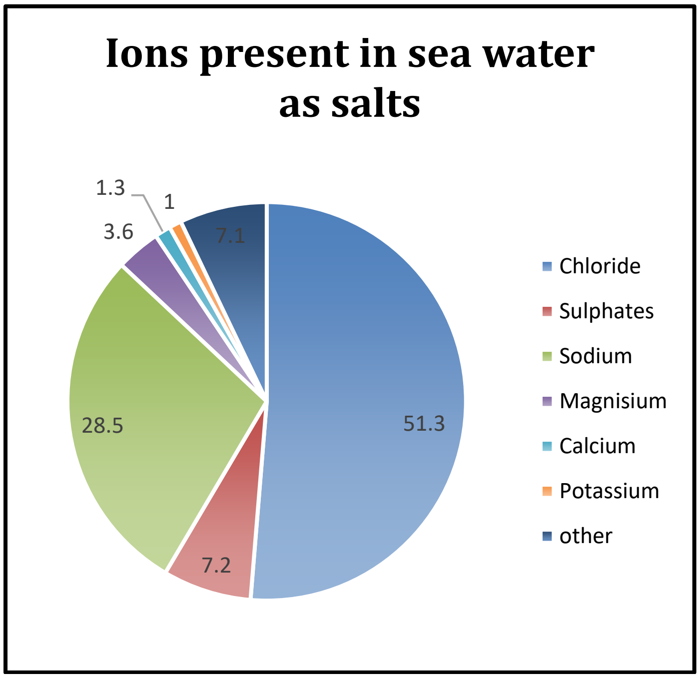

Fig. 1 Ions present in sea water as salt (in %)[3]

Table 2. Effect of salts of sea water on compressive strength of concrete[13]

Salts of sea water (in %)	Reduction in compressive strength (in %)
5% Sodium Chloride	25-30
Carbon di Oxide	15-20
1% Sulphate	3.9-4
0.5% Sulphate	9-10

Setting time of cement was also influenced by the quality of water. When fresh water is used in cement the normal setting times comes in range between 30 min to 600 min[11]. The initial setting time should not be less than 30 min and the final setting should time more 10 hours[11]. As per studies, the sea water reduces the setting time by 32%, however, it can be countered by using retarding admixtures[14]. As per standard textbook for building material by SK Duggal, special types of cement should be used in marine or saline environments and the coastal region which are prone to sulphate attacks[6]. These special cements such as portland slag cement, sulphate resisting portland cement, high alumina cement provides better performance than ordinary portland cement. Researchers suggest that low water-cement ration as 0.26 with admixtures such as fly ash, blast furnace slag can reduce the chances of corrosion in steel bars[15].

2.2 Industrial and domestic waste water

Wastewater refers to water that comes from various sources, including human activities such as water from sinks used for food preparation, bathing, washing clothes, dishwashers, sinks, and drains, as well as water from laundries, car washing stations, textile mills, and cold storages. In India, a country already facing significant water scarcity, there is growing concern about the need to recycle and reuse wastewater in all relevant sectors, thus reducing the need on new drinking water. According to a study, the sewage waste water cannot be directly utilised in concrete since it contains dangerous substances[16]. Prioritise the treatment of waste water before utilising it in concrete by implementing a cost-effective yet secure approach. Failure to do so may result in uneconomical concreting due to the expenses associated with processing the untreated water. If the procedure is cost-effective and highly efficient, it will yield the utmost advantage to both the municipality and the construction industry[16].

Table 3. Permissible limits of physical and chemical parameters

Parameter	Max. permissible limit	References
Appearance	Colorless	[11]
Odor	Odorless	[11]
Turbidity	None	[11]
Hardness	600 mg/l	[11]
pH	6.5-8.5	[11]
	>3	[19]
	7-9	[21]
Total solids	50000 mg/l	[22]
	5000-10000 mg/l	[3]
	4000 mg/l	[3]
	2000 mg/l	[11]
Dissolved solids	50000 mg/l	[3]
	2000 mg/l	[11]
Suspended solids	2000 mg/l	[11]
Inorganic solids	3000 mg/l	[11]
Alkalinity	600 mg/l	[11]
	1000 mg/l	[23]
Carbonates	1000 mg/l	[11]
Bi-carbonates	400 mg/l	[11]
Chlorides	2000 mg/l for plain concrete 500 mg/l (For RCC)	[11]

2.3 Brackish water

Brackish water refers to the mixture of sea water and fresh water, characterised by a TDS (total dissolved solids) level that falls between that of fresh water and sea water[24]–[26]. Brackish water, particularly brackish groundwater, is abundant in most continents and is found in quantities that are nearly equivalent to or greater than fresh groundwater and surface waters[24]. Brackish water, which is produced by industries like oil production firms, has been extensively studied for its potential use in cement concrete. Research has shown that concrete made with brackish water can achieve the desired compressive strength. Researchers recommended conducting tests on the brackish water to measure its BOD, COD, and assess its chemical and physical characteristics. These measurements should adhere to the allowed limits specified in table 3[29], [31], [32]. It is generally recommended to test samples for mechanical and durability properties before using concrete in actual construction. This is particularly important for structures of high significance, such as high rise buildings and hospitals, in order to avoid the use of water that may be unsuitable.

3. CONCLUSION

Sea water and recycled waste water can be utilised in cement concrete due to their impurities and solid components, which can expedite the setting period and promote early strength increase. This will not only decrease the empty spaces but also improve the durability of the concrete. However, there are numerous obstacles to overcome when it comes to utilising sea water and recycled water. These include factors such as the surrounding environment, geographical location, temperature and humidity conditions, as well as the availability of additional resources like special cements and admixtures. It is imperative to take these factors into consideration before making use of sea water and recycled water. Finally, this brief review can be summarised with the following conclusions.

- The utilisation of recycled waste water in concrete production might enhance its density by reducing its workability through the presence of small particles and a decrease in water content.
- The presence of tiny contaminants in recycled waste water can lead to a decrease in voids and subsequently lower water absorption, thereby reducing the likelihood of chemical attack. Therefore, concrete has the potential to increase in durability.
- According to IS 456 standards, if the compressive strength of concrete achieved using waste water is approximately 90% of that achieved using fresh water, it is considered acceptable.
- Sea water is suitable for use in regular concrete construction, but it should be avoided in reinforced concrete construction (RCC).
- When using sea water to make concrete, it is advisable to utilise specialised cements such high alumina cement or sulphate resistance cement.
- Recycled water may be utilised in RCC work alone following an assessment of its chemical and physical properties to ensure they fall below acceptable limitations.
- A significant level of supervision is strongly advised while utilising sea water and reclaimed waste water. The utilisation of seawater and reclaimed wastewater can significantly conserve freshwater resources, hence mitigating the severity of water scarcity.

REFERENCE

[1] “World Population Clock: 7.9 Billion People (2022) - Worldometer.” https://www.worldometers.info/world-population/ (accessed Mar. 10, 2022).

[2] “Water - India Facts | International Development Enterprises (India).” https://www.ide-india.org/content/water-india-facts (accessed Mar. 10, 2022).

[3] Trivedi. Ramakant, Yadav. Umesh, and Sharma. Kamalkant, “Effect of Calcined Clay and PVC Waste Powder on Concrete Properties,” Sustainable Construction Materials, 2023, [Online]. Available: https://rsya.org/scm-v3i1-01-10/

[4] Patel. Shubham and Kumar. Anant, “Utilizing Bamboo as Reinforcement in Structural Concrete Elements,” Sustainable Construction Materials, 2023, [Online]. Available: https://rsya.org/scm-v3i1-30-38/

[5] Islam. Parvez, Ahmad. Zikri, and N. Begum, “Concrete with Rock Sand Filler and Based on Metakaolin: Experimental Analysis,” Sustainable Construction Materials, 2022, [Online]. Available: https://rsya.org/scm-v2i1-33-39/

[6] S. K. Duggal, *Building Materials*, 3rd ed. New Age International (P) Limited, Publisher,

2003.
[7] Johns. Oliver and Tayor. Lily, "Study of Curing Time Impact on Geopolymer Concrete and Mechanical Properties," Sustainable Construction Materials, 2023, [Online]. Available: https://rsya.org/scm-v2i1-16-24/
[8] "What percent of Earth is water?" https://phys.org/news/2014-12-percent-earth.html (accessed Mar. 09, 2022).
[9] "Sea water." https://www.sciencedaily.com/terms/seawater.htm (accessed Mar. 10, 2022).
[10] S. K. Kaushik and S. Islam, "Suitability of sea water for mixing structural concrete exposed to a marine environment," *Cem. Concr. Compos.*, vol. 17, no. 3, pp. 177–185, Jan. 1995, doi: 10.1016/0958-9465(95)00015-5.
[11] IS 456, "IS 456 : 2000 - Plain and reinforced concrete - code and practice," *Bur. Indian Stand.*, 2000, doi: 624.1834 TAY.
[12] "Seawater in the Mixture." https://www.concrete.org/publications/internationalconcreteabstractsportal/m/details/id/10141 (accessed Mar. 10, 2022).
[13] Nobuaki Otsuki, Tsuyoshi Saito, and Yutaka Tadokoro, "Possibility of Sea Water as Mixing Water in Concrete," *J. Civ. Eng. Archit.*, vol. 6, no. 11, 2012, doi: 10.17265/1934-7359/2012.10.002.
[14] S. Kubba, "Green Building Materials and Products," *Handb. Green Build. Des. Constr.*, pp. 257–351, 2017, doi: 10.1016/B978-0-12-810433-0.00006-X.
[15] S. Ozaki and N. Sugata, "Sixty-Year-Old Concrete in a Marine Environment," *Spec. Publ.*, vol. 109, pp. 587–598, Aug. 1988, doi: 10.14359/2073.
[16] F. Sandrolini and E. Franzoni, "Waste wash water recycling in ready-mixed concrete plants," *Cem. Concr. Res.*, vol. 31, no. 3, pp. 485–489, Mar. 2001, doi: 10.1016/S0008-8846(00)00468-3.
[17] G. R. Babu, "Effect of wastewater on properties of Portland pozzolana cement," *AIP Conf. Proc.*, vol. 1859, no. 1, p. 020103, Jul. 2017, doi: 10.1063/1.4990256.
[18] O. A. El-Nawawy and S. Ahmad, "Use of treated effluent in concrete mixing in an arid climate," *Cem. Concr. Compos.*, vol. 13, no. 2, pp. 137–141, 1991, doi: 10.1016/0958-9465(91)90009-7.
[19] J. Tay and W. Yip, "Use of Reclaimed Wastewater for Concrete Mixing," *J. Environ. Eng.*, vol. 113, no. 5, pp. 1156–1161, Oct. 1987, doi: 10.1061/(ASCE)0733-9372(1987)113:5(1156).
[20] N. Su, B. Miao, and F. S. Liu, "Effect of wash water and underground water on properties of concrete," *Cem. Concr. Res.*, vol. 32, no. 5, pp. 777–782, May 2002, doi: 10.1016/S0008-8846(01)00762-1.
[21] *General Specification for Civil Engineering Works (GS), 2006 Edition Volume 2.* Hong Kong, 2006.
[22] R. Rondahaim, *Users Guide to ASTM Specification C94 on Ready Mixed Concrete ASTM Manual Astm Manual Series Mnl 49*. .
[23] A. M. Neville, *Propeties of concrete*. London: Longman: London: Longman, 1995.
[24] Y. Shevah, "Adaptation to Water Scarcity and Regional Cooperation in the Middle East," *Compr. Water Qual. Purif.*, vol. 1, pp. 40–70, 2014, doi: 10.1016/B978-0-12-382182-9.00004-9.
[25] S. Gray, R. Semiat, M. Duke, A. Rahardianto, and Y. Cohen, "Seawater Use and Desalination Technology," *Treatise Water Sci.*, vol. 4, pp. 73–109, 2011, doi:

10.1016/B978-0-444-53199-5.00077-4.
[26] M. K. Gingras *et al.*, "Estuaries," *Dev. Sedimentol.*, vol. 64, pp. 463–505, 2012, doi: 10.1016/B978-0-444-53813-0.00016-2.
[27] M. N. J. and R. P., "Treatment of oil-contaminated soils for identification and classification," *Geotech. Test. J.*, vol. 18, pp. 41–49.
[28] Guo. Tai, Feng. Shao, and Vu. Xiu, "Utilization of Red-Mud as a Partial Replacement for Cement in Concrete," Sustainable Construction Materials, 2022, [Online]. Available: https://rsya.org/scm-v2i1-25-32/
[29] R. Taha, A. Al-Rawas, S. Al-Oraimi, H. Hassan, and M. Al-Aghbari, "The Use of Brackish and Oil-Contaminated Water in Road Construction," *Environ. Eng. Geosci.*, vol. 11, no. 2, pp. 163–169, May 2005, doi: 10.2113/11.2.163.
[30] Khatri. Pooja, Singh. Bhagmant, and K. Sapna, "Review of the Mechanical Behavior of Geopolymer Concrete," Sustainable Construction Materials, 2022, [Online]. Available: https://rsya.org/scm-v1i1-28-33/
[31] R. A. Taha, A. S. Al-Harthy, and K. S. Al-Jabri, "Use of Production and Brackish Water in Concrete Mixtures," *Int. J. Sustain. Water Environ. Syst.*, vol. 1, no. 2, pp. 39–43, 2010, doi: 10.5383/swes.01.02.001.
[32] V. I. Rich and R. M. Maier, "Aquatic Environments," *Environ. Microbiol. Third Ed.*, pp. 111–138, 2015, doi: 10.1016/B978-0-12-394626-3.00006-5.