International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Sustaining Aquifer Integrity and Terrestrial Ecosystems: A Holistic Frame Work for Groundwater Conservation, Pollution Abetment and Soil - Vegetation Preservation Through New Construction Methodology

Mr. Shailendra Yadav[1], Prof. Anupam Kumar Gautam[2]

[1]Researcher, Environmental Engineering, MUIT
[2]Assistant Professor, Environmental Engineering, MUIT

Abstract:
Construction activities throughout the country are significantly responsible for Environmental Pollution accounting for 27% of air pollution, 40% of water bodies' contamination along with Rapid Groundwater depletion and ecosystem disruption. Sustainable construction practices are essential to counter these impacts. We conducted this research to identify the sources and came up with a sustainable solution to protect natural Ground water and Soil Fertility to promote sustainable environment for future generations.
Pre-fabricated construction can eliminate environmental pollution in the construction industry by reducing Carbon emissions, Controlling emissions, minimizing water usage and prevention of water pollution of natural reservoirs. Specialised units can manufacture components in controlled environments, leading to reduced water consumption and wastage, and waste emissions compared to on-site construction. Pre-fabricated components can also be designed to optimize material use and incorporate recycled content, further minimizing the environmental impact by the less use of natural resources. This research suggests that pre-casting\pre -fabrication can lead to a 10% carbon reduction and 70 % less water consumption for every cubic meter of concrete compared to traditional methods. Specific indicators are developed to evaluate to control the water usage and waste generation.

Keywords: Combating Groundwater Scarcity, Aquifer Integrity, pre-fabricated structures, sustainable construction, balancing water security.

Introduction:
Conventional construction activities are consuming more water than the actual requirement, which is causing a major issue of water scarcity in the urban areas, degrading the water quality of the natural reservoirs and sources by accumulation of construction sediments and construction waste into the stream. Due to prolonged use and wastage of groundwater in this construction sector it is found that the water table has drastically reduced to lower levels and it can deplete aquifers faster than they can be naturally replenished. In this research we have analysed various parameters which are influencing the

environments on different levels. Uncontrolled construction activities are having serious consequences on the environment of the areas which are indulge in the major construction activities, in our research we found cities which are in Tier-1 and Tier-2 categories are severely affected with pollution caused by the construction industry. In a detailed study we have identified impacts caused by the construction industry which are removing green zones from the urban area.

In our research we focused on the major impacts of construction activities over the following points affected by this industry-:

1. Water Scarcity, Shortage and Water Pollution.
2. Soil Degradation and Contamination.
3. Construction Waste generation and Disposal Challenges.

These 2 important elements of earth (Water and Soil) which are responsible for making earth suitable for living are polluted and disturbed by our own uncontrolled construction practices. In order to rectify these sustaining problems, we have created an approach towards the sustainable solution and found that by following this different approach towards construction method we can eliminate the degree of impact up to maximum, which can transform the construction industry in a positive way to resolve all of these issues.

.

4. Literature survey:

In past researches there is always a concern about the pollutions and their causing elements and it identifies them. Regarding construction activities no serious steps are taken into considerations to mitigate the environmental pollution caused by this dynamic industry. Similar to water pollution it identifies chemical spills and various factories with unregulated discharge in the water bodies. They were not able to establish co relation with this industry. In various studies it was found that construction activities extracts excess of groundwater which is way more than the actual required limits. It exploits the natural water resources by improper extraction, usage and distribution systems. But now this industry has gained heights in significant contribution in polluting the environment in multiple ways. Here in our research we have identified different modules to study and solve the emerging problem of groundwater .

5. Problem Definition:

In detailed review we found this a very serious issue and it is mandatory to bring sustainable solutions for this industry. Now we discuss in detail about all the above mentioned issues.

5.1. Water Scarcity, Shortage and Water Pollution.

Another major impact assessment is done with water, which is used during the construction process and also which is polluted during the construction activities. Construction activity uses water to a significant extent for many operations, materials, and on-site activities, and the availability of potable water for building construction is a matter of concern. Consumption of water in building construction is expected to increase across the globe, particularly in developing countries like India, because of the demand for urban development and housing for all. Hence, water efficiency in building construction is a matter of concern when it is used poorly and inefficiently.

Construction activities can have long-lasting impacts on receiving water bodies, especially when they receive polluted urban run-off**.** This suggests that the consequences of construction-related pollution can have long-lasting effects on water quality and may require on-going efforts to mitigate and manage the impacts.

5.1.1 How this Construction Industry contributes in consuming the water extensively with no control over the wastage:-

- Public buildings have larger footprints than residential buildings because of their intensive consumption of steel and cement and larger covered area which requires more consumption of water.
- Compared to rural residential buildings, the footprints of the urban residential buildings are 55–130% higher. Hence resulting in continuous depletion in water table in urban areas.
- Due to extensive involvement of residing manpower in urban construction projects, per capita demand of water is rises in tremendous amount which can multiply the usage of water up to 130% of total water requirements of construction activities.
- Continuous extraction and poor distribution system of groundwater through bore holes at construction sites to fulfil the demand of residing manpower is the main reason for the wastage and excess extraction of groundwater. This will significantly depletes the aquifers and it will be a troubling situation for the urban areas. **(Similar example came in light in Bangalore, India, when there was crisis for the water. As there was no availability of water for washing, drinking and even there was no availability for bathing.**
- The National Remote Sensing Centre and 2019 study estimated that India's average annual water resource availability was 1,999.20 billion cubic meters (BCM). The country's usable water is thought to be 1,126 BCM in 2023 due to geographical, hydrological, and other limitations.
- In a detailed analysed model of multi-story residential apartment structure it was determined that the inherent and induced water levels were 25.6040 kl/sqm and 2.0kl/sqm, respectively, of floor area. As a result, the construction water footprint came to 27.6040 kl/sqm. But the actual requirement of the water for only civil construction related activities was 0.6 kl/sqm. Excess consumption was 27.0 kl/sqm .
- In a different research it comes as a result that a conventional building construction in Jammu uses 43.7 kl/sqm of embedded water per square meter. 40.3% of the total embodied water in buildings comes through indirect water consumption.
- Water required for curing of materials like brickwork in cement mortar, cement plaster, and concrete is considered as 10% (by volume) by bricks and cement mortar and 5% (by volume) by cement and concrete for 7 to 14 days on a daily basis.

5.1.2. How this Construction Industry contributes in Water pollution:-

- Accumulation of the particulate matters and insoluble particles such as cement , dust and gypsum particles in the water bodies resulting in the reduction in the percolation of water in the ground which hampers the recharge of aquifers .
- During construction works, which are typical human activities during urban development, it is likely that the levels of dissolved solids or salinity in water will be elevated above natural levels. Regarding suspended solids, previous studies have shown that construction works lead to relatively high levels of suspended solids in streams because of the wash off of construction sites that release into runoff.
- Runoff from construction sites containing sediment, chemicals, and debris can contaminate water bodies, impacting aquatic life and potentially human health.
- Improper waste disposal and spills of hazardous materials can also lead to water pollution.

5.2. Soil Degradation and Contamination.

Soil Contamination is also a resultant of this construction industry. Continuous degradation of soil and contamination is prominently arising due to certain factors:

- Improper handling of raw materials lying at construction sites.
- Spreading and disposal of debris with dust and particulate matter in the open which is carried by strong winds in significant time.
- Sedimentation of cement particles, gypsum, silica, stone dust over the ground causing toxicity in soil resulting in soil degradation.
- Mixing of soil with leftover raw materials over a period of time due to improper material management and poor construction practices promotes the contamination of soil by losing its adhesive strength and fertility.

5.3. Waste generation and Disposal Challenges.

Waste generation and disposal is one of another major environment related issue which is a by-product of the construction industry. Construction projects generate large volume of garbage and debris which is generally the demolition waste. A study found that in India building and demolition operations generated 765 tons of debris due to demolition of old structures which are demolished to expand and renovate.

5.3.1. It is becoming more challenging due to certain factors:-

- Construction industry generates large amount of loose garbage like packaging of polymers and other cardboard which end up in landfills or incinerators, which emit smoke and huge carbon emissions on burning into the atmosphere. Both ways of disposal have negative impact on the environment.
- Contraction trash is one of the top contributors to industrial waste. Demolition project contribute to nearly 90% of that amount meaning most of the demolished material is never re used.
- Loose and improper collection management of waste in construction sites results in littering of waste resulting the waste end up in river bodies causing degradation of water and aquatic life.
- Landfills are the major disposal sites for debris and other structural components including concrete and broken bricks which hamper the process of decomposition of waste.
- Due to heavy weight of debris and demolition waste sometimes it is not disposed in landfills but it is disposed near the construction sites into the soil to reduce the disposal cost.

6. Rectification Methods / Approach:

In this research we have calculated the merits of certain construction methodology over the conventional methods of constructions after that we found that there are implications showing positive signals which enhance the environmental conditions.

We find the solution in the form of Pre-fabricated modular technology (PMT). In this tech various components of structures generally of residential projects which are more prominent in the urban areas , are calculated , designed and fabricated in a pre-planned and sustainable factory under controlled conditions in which it kept in mind to mitigate all the above mentioned problem which are affecting the environmental conditions.

Conventional cast in-situ, precast and prefabricated construction are construction methodologies with increasing construction modularity. Construction methodologies and modularity, in turn, are determinant of sustainability on site. This paper analyses 5 construction projects in **Rail Coach Factory, Rae Bareli, U.P., India**. Spanning a substantial period of 10 years for a systematic comparison on their construction methodology and sustainability performance. Specific indicators are developed to evaluate projects sustainability performance with various levels of prefabrication.

Use of **Ultra-High Performance Concrete (UHPC)** is a revolutionary material that has been gaining popularity in the field . UHPC is a type of concrete that is known for its exceptional strength, durability, and versatility. It is made with a precise combination of ne sands, cement, silica fume, bars, and super plasticizers, resulting in a material that is far superior to traditional concrete in terms of performance and durability. One of the key characteristics of UHPC is its incredibly high compressive strength, which can exceed 20,000 psi. This strength allows for the creation of slender and innovative architectural designs that were previously not possible with traditional concrete. UHPC also has a very low permeability, making it highly resistant to corrosion and environmental degradation. This durability ensures that structures built with UHPC will have a longer lifespan and require less maintenance over time.

Another benefit of using UHPC in construction process is its rapid setting and high early strength development. This allows for faster construction times and reduced labour costs, as structures can be erected more quickly and efficiently than with traditional concrete. Additionally, the high early strength of UHPC means that structures can be put into service sooner, reducing downtime and increasing productivity on construction sites.

Structural design principles for precast concrete elements are crucial in ensuring the safety and durability of precast concrete construction projects. As civil engineers, it is essential to understand these principles to effectively design and build precast concrete structures. By following best practices in structural design, you can optimize the performance and efficiency of precast concrete elements.

6.1 Social sustainability

In relation to social sustainability in construction, the safety and working environment of construction workers are key considerations. Firstly, safety is considered as one of the many methods in improving sustainability. As accident rate was kept based on the entire project lifecycle, further attributing the associated injuries or fatalities to specific operations of different construction methods is difficult. Overall it shows that precast and prefabricated construction could provide a safer working environment for workers and therefore reduce the accident rate. Jaillon and Poon (2008) have mentioned that the use of prefabrication would allow a better and safer working environment for construction workers. A report by the Construction Industry Review Committee (Construction Industry Review Committee and Tang, 2001) also recommends prefabrication methods as feasible ways to reduce accidents associated with the cast in-situ construction method. Other benefits of prefabricated construction towards workers health include a reduction of noise and dust onsite, which, in turn, can reduce the degradation on occupational health of workers. Apart from improved occupational health and safety of workers, the study demonstrates that productivity, site management and quality of works have increased when adopting prefabricated construction

Academic research and world organisations have also included a reduction of resource consumption as one of the seven indicators of sustainable construction (Zhong and Wu, 2015). Considering the reducing labour resources in Tier 1 and Tier 2 cities, prefabricated construction enables a reduction in required human resources onsite, as most construction materials are built offsite and only required installation onsite. Labour shortage in the construction industry is severe among many big cities. This study also suggests that prefabricated construction allows for a better supervision of labour when compared to the conventional cast in-situ method.

6.2 Economic sustainability

During the research many evidences indicate that higher levels of construction modularity can effectively reduce the materials required for construction projects. With better quality provided by offsite construction, reworks onsite and material wastage are minimized. Therefore, the economic liability for materials can also be reduced. A study focusing on the performance of prefabricated construction has shown that it can significantly reduce material cost by 56% when compared to the cast in-situ method (Jaillon and Poon, 2014). As prefabrication allows quality control over production, the cost for material deliveries, storage or reworks is also less of a concern. It provides a chance to closely monitor the production in controlled facility.

7. Results / Discussion: Pre-Fabricated Modular Technology (PMT) as a Sustainable Solution.

Pre-Fabricated Modular Technology (PMT) can mitigate water related issues and pollution in the construction industry by reducing water usage and a significant reduction in PM2.5 and PM 10 emissions, minimizing waste, and. Factories can manufacture components in controlled environments, leading to reduced water usage and waste emissions compared to on-site construction. Precast concrete can also be designed to optimize material use and incorporate recycled content, further minimizing the environmental impact.

During this detailed research we found that PMT technology can contribute to the environment and change the scenario of the construction industry in a very positive way. It helps in replenishing the ground water by conserving and limiting the extraction and water pollution to a greater extent. We found certain results during the study:

7.1 Reduced water requirement and reduced PM2.5 and PM10 emissions.

Specialised Factory Production: Manufacturing pre-fabricated concrete components in controlled factory settings allows for optimized water usage with no water wastage management systems and water polluting emissions compared to on-site construction. Complete control over the waste discharge into the ground and water bodies.

Efficient Material Use: Precast design can optimize material use, potentially reducing the amount of concrete required and the associated carbon emissions from cement production. Also regulates the optimum use of raw materials conserving the limited resources.

Carbon and PM2.5/PM10 Reduction: Studies suggest that pre casting or pre fabricating can lead to a 10% carbon reduction for every cubic meter of concrete compared to traditional methods and reduce energy consumption in the process of casting. Use of fogging systems in the factory sections helps in controlling the particulate matter and dust.

Low-water content Cement mix: The precast industry actively seeks to reduce cement and water usage and replace it with alternatives like fly ash, slag cement, and silica fume, which further reduces emissions and combines all with specified design mix to control water cement ratio.

7.2. Minimum Construction waste generation.

Minimizing Waste: Precast construction generates less waste due to its controlled manufacturing process and the use of reusable formwork. It also control the waste related to packaging materials and store them in controlled conditions. Zero waste policy is maintained in the pre cast facility.

Waste Recycling: Waste concrete from precast plants can be recycled for use in other construction projects or as fill materials. Water used for curing of casted elements is also recycled and used in further curing process. It minimise the use of water in the construction process.

Reusable Formwork: Formwork and finishing materials can be reused multiple times, reducing the need for new materials and associated waste.

7.3. Water Recycling Facility:

Optimised Design: Precast components can be designed to improve building performance, so the facility is also designed in a way to optimise the water accountability by consuming the water in construction and fabrication process by recycling it. It also focus on the rain water harvesting and , leading to reduced energy consumption .

Reduced Energy Use: By manufacturing components in a factory setting, energy consumption is optimized and emissions are reduced compared to on-site construction. Components are customised to consume least power consumption during installations fabrication and errection .

7.4. Other Benefits:

Reduced Noise and Dust: Precast construction reduces noise and dust pollution on site compared to traditional construction methods. Use of fogging systems in the loading and unloading areas of raw materials control the flow of dust particles , later the water is recycled to use in curing and other defined processes on site .

Faster Construction: Precast construction can accelerate the construction process, reducing the time spent on site and minimizing the environmental impact of long-term construction activities reducing the construction cost and minimizing the engagement of manpower and machineries.

Improved Safety: Precast plants can offer a safer working environment compared to traditional construction sites, reducing risks associated with manual labour and machinery. Due to easy installation process skilled manpower can assemble it with least risk of accidents.

7.5 DURABILITY

A key factor in building reuse is the durability of the original structure. Precast concrete panels provide a long service life due to their durable and low-maintenance concrete surfaces. A precast concrete shell can be left in place when the building interior is renovated. Annual maintenance should include inspection and, if necessary, repair of joint material. Modular and sandwich panel construction with concrete exterior and interior walls provides long-term durability, inside and out. Precast concrete construction provides the opportunity to refurbish the building if the building use or function changes, rather than tearing it down and starting anew. These characteristics of precast concrete make it sustainable in two ways:

It avoids contributing solid waste to landfills and it reduces the depletion of natural water resources and production of soil and water pollution caused by new construction.

8. Conclusion:

we would like to conclude that for the preservation of our eco system it is mandatory to safeguard the parameters of environment. Water Scarcity is becoming a major issue around the globe . It is the need of hour to control the deteriorating water crisis of environment by adapting the pre-fabricated technology (PMT) in the construction industry especially in the urban areas where the density of the population is very dense and water requirement of per capita is more. This technology not only reduces the pollution but also conserve the most precious element that is **WATER**.

9. References:

1. Value losses and environmental impacts in the construction industry – Trade offs or correlates?

Philipp Dräger, Peter Letmathe
RWTH Aachen University, Chair of Management Accounting, Templergraben 64, Aachen, 52062, Germany.
https://doi.org/10.1016/j.jclepro.2022.130435.

2. Investigation of dust exposure and control practices in the construction industry: Implications for cleaner production
Clyde Zhengdao Li [a], Yiyu Zhao [a], Xiaoxiao Xu [b]
College of Civil Engineering, Shenzhen University, Nanshan, Shenzhen, China
Department of Civil and Construction Engineering and Centre for Sustainable Infrastructure, Swinburne University of Technology, Hawthorn, Australia
https://doi.org/10.1016/j.jclepro.2019.04.174

3. Analyzing the potential local and distant economic loss of global construction sector due to water scarcity
Chenglong Wang [a], Chenyang Shuai [a b], Xi Chen [c], Wei Huang [a], Wenhua Hou [a], Bu Zhao [d b], Jingran S un [e]
School of Management Science and Real Estate, Chongqing University, Chongqing, China
School for Environment and Sustainability, University of Michigan, Ann Arbor, MI, USA
College of Economics and Management, Southwest University, Chongqing, China
Department of Environmental and Sustainable Engineering, University at Albany, State University of New York, Albany, NY, USA
Center for Transportation Research, The University of Texas at Austin, Austin, TX, USA
https://doi.org/10.1016/j.eiar.2024.107667

4. A study on the response of waterbird diversity to habitat changes caused by ecological engineering construction
Yang Liu [a 1], Phyoe Marnn [a 1], Haibo Jiang [a], Yang Wen [b], Hong Yan [c], Dehao Li [a],
https://doi.org/10.1016/j.ecoleng.2024.107358

5. Decisive design and building construction technologies vis-à-vis embodied water consumption assessment in conventional masonry houses: Case of Jammu, India
Anoop Kumar Sharma , P.S. Chani
Built Environment Lab, Indian Institute of Technology (IIT) Roorkee, 247667, India
School of Architecture and Landscape Design, SMVD University Katra, 182320, India
https://doi.org/10.1016/j.enbuild.2022.112588