Chemical Properties of Washed and Sieved Offshore Sand

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Abstract - **This study tested the chemical properties of washed and sieved off-shore sand available at Muthurajawela sales stockpile of Sri Lanka Land Development Corporation (SLLDC). Chloride, acid-soluble Sulphates and total Sulphur contents in accordance with SLS 1397 standards were tested. Testing indicated that all the key parameters were significantly lower than the allowable limit, which points to the fact that the constructions are not restrained. Decontamination by washing and sieving is effective in eliminating or removing potentially harmful salts and other impurities commonly found in marine sands, thus, limiting the chance of reinforcement corrosion, sulphate attack and structural degradation. On the whole, the experimented offshore sand shows that it can be used and applied in reinforced concrete and plain concrete use, guaranteeing durability and the structural safety of building constructions.**

INTRODUCTION

Along with the Covid 19 pandemic outbreak in 2020 the Sri Lankan construction industry faced a collapse (Weerakoon, et al., 2020). This was enhanced by the country's economic crisis prevailed in 2022. But currently, it is recovering from its collapse. Since infrastructure development, housing construction and urbanization have advanced the construction sector, river sand has been used in much greater quantities. In conventional concrete and mortar work in Sri Lanka, it normally contain river sand due to their excellent properties of being strong, fine and being suitable to handle (ICTAD, 2008).

For years, the construction industry in Sri Lanka has largely relied on river sand because it is easy to obtain locally and widely recognized. Yet, this arrangement has increased problems for both environment and the economy. Mining sand from rivers without rules has allowed the waterway's banks to erode, the riverbeds to subside and has caused damage to habitats for aquatic species and let saline water reach settlements lower than where the mining occurs (Gamage, et al., 2020) . In addition, losing easy to reach sand from rivers has made materials scarce and expensive, causing concerns for contractors and developers during construction.

River sand mining also results in changes in both the quality and quantity of available water. When riverbeds lower, it reduces the amount of water that aquifers receive, hurting both wells and systems used for local farming. Dirty and sedimented water causes pollution and harm to the environment, including species in rivers such as fish, tortoise and aquatic insects (Cooray & Gamage , 2016). The people living around mines suffer from conflicts because they often have less water and more problems with environmental dangers.

Too much bank erosion and scouring around make it more likely for bridges and roads to fail, along with irrigation networks. As a result, maintenance costs go up and the public is more at risk (Hettiarachchi, 2019). As this form of mining is typically unlawful and informal, it contributes to corruption and makes well-managed resources harder to achieve. It also leads to tensions among authorities, miners and public.

With infrastructure growing quickly and more cities developing, the need for natural materials has greatly increased, especially for river sand (Gnanothayan & Kauskale, 2022). For years in Sri Lanka, river sand has been mainly used as the preferred fine aggregate by domestic users for making concrete and masonry. But the river sand has become the most expensive fine aggregate in Sri Lanka due to the uncontrolled sand extraction. As a result, authorities and those who protect the environment are exploring renewable sources such as manufactured sand and offshore sand to address construction demands with minimum ecological side effects.

Sri Lanka Land Development Corporation (SLLDC) is the only government organization which supplies offshore sand to the construction industry since 2006. Offshore sand is mined from the borrow pit in the ocean and pumped to the SLLDC land. SLLDC has reserved a borrowing site which is located 10-15 km away from shore at Kerawalapitiya. SLLDC has successfully completed four numbers of offshore sand mining and pumping projects during the past (Niroshan, et al., 2021).

Over the last twenty years, dredged sea sand material has been used in several construction works such as construction of highways and government infrastructure works and reclamation works (Koswaththa, et al., 2025) . In some of the mega infrastructure development projects of Sri Lanka, including the Colombo - Katunayake expressway, the Colombo Port Expansion Project (CPEP) and the Colombo Port City project, required a substantial amount of fine aggregate and offshore sand was used there while considering the environmental damage and the financial aspect. Sea sand was to start with restricted to non - structural applications as a result of concerns over the chloride content and impurities. With the improvement in research and processing however, the sea sand has been adapted to structural concrete and therefore, sea sand is a popular substitute for river sand and manufactured sand.

As a result of the COVID 19 pandemic and government ban on river sand excavation, the supply of river sand greatly reduced. Therefore, sea sand use grew at the time period of 2020 (Gamage, et al., 2020). The post pandemic economic situation in Sri Lanka is where the country suffered the most economically significant crisis during its history. The construction industry had also been equally hit by the highly shrinking demand for materials in construction meaning that the demand of sea sand was also downed portraying the general slowdown of the industry.

It has been observed that seasonal changes exert an impact on sea sand mining in Sri Lanka, especially the southwest monsoon (May to September) that may change the availability and distribution of sand along the western coast (Niroshan, et al., 2021). A very high wave - energy and the presence of forceful coastal currents during this time may lead to serious erosion, sediment transport and siltation and irregular sea sand deposits which affect ongoing mining activities.

Figure 1 - Offshore sand pumping

The very recent project of the sea sand mining by SLLDC involved the Cutter Suction Dredger (CSD) technique. A layer of 300mm thickness was dredged in one turn. The benefit of using this method is an increased rate of production and the capability of disposing slurry of sand (Figure 1) over a long distance through pipelines. Dredging process implies upcasting suction tubes (the drag head) to the bottom of the sea, pumping the mixture of sand and seawater, and pumping it into the hopper of the vessel. After the vessel is loaded to full capacity, it is sailed close to the shore and the sand pumped on through floating pipes to the stockpile area via a booster station (Koswaththa, et al., 2025). The dredging cycle requires an approximate time of 4 hours inclusive of loading it, transporting it to a position where it will be unloaded as well as bringing it back to the mining site.

The objectives of this study are as follows.

1. To evaluate the chemical compatibility of washed and sieved offshore sand for structural applications.
2. To assess the effectiveness of washing and sieving offshore sand in reducing the impurities.
3. To investigate the use of offshore sand as a sustainable alternative for river sand.

Methodology

A. Sample Collection

On-site Sampling was carried out at the washed and sieved offshore sand sales stockpile at Muthurajawela from different locations of the stockpile. The washed offshore sand by the washing plant is stocked until the sales in the sampling location. 2kg weigh samples were collected from the mid-level of the stockpile. The samples were collected weekly so that the sampling locations would cover the whole area of the stockpile. The samples were collected in accordance with the EN 932-1:1996. The collected samples were tested at the National Building Research Organization (NBRO) laboratory.

B. Testing for Chloride Content

Sand samples had been oven-dried, cooled and sieved while the larger particles were crushed to get them passed through the sieve. Its weight was taken out and placed in a flask and distilled water added in proportion of 1:1 mass, thoroughly stirred by using a shaker, up a 60 minute to dissolve water-soluble chlorides. The slurry was filtered through filter papers up until the receiving 100 ml of the solution. Chloride was analyzed by titration with silver nitrate. The amount of precipitated chloride was calculated and expressed as a percentage of chloride ions by mass of dry aggregate.

C. Testing for Acid Soluble Sulphates

Samples of representative offshore sand were dried in an oven, cooled and sieved. A sample of 20 g was precisely weighed and transferred into a beaker and cold water was added. Concentrated hydrochloric acid was added to the sample while stirring. The suspension had been heated for 15 minutes and it was stirred periodically to break up the solids. The warm extract was filtered, cleaned off and diluted. One of the aliquots had been almost brought to boil and barium chloride solution added in order to precipitate the sulphate as barium sulphate. The mixture had been digested, filtered, ignited, cooled and weighed and sulphate had been dried as SO_3.

D. Testing for Total Sulphur Content

The sample of offshore sand had been oven dried and weighed and then coarsely grounded. One of them was a measured amount that had been exposed to hydrochloric acid so as to liberate the sulphates. The sample was filtered, diluted and heated acids until sulphates were precipitated with barium chloride. The barium sulphate product that resulted as a precipitate had been washed, dried, ignited and weighed. The weight of this precipitate had been computed as total Sulphur and as a percentage of the original sand sample.

Results

1. Testing for Chloride Content

Following results were obtained for the testing of chloride content in the washed and sieved offshore sand sample.

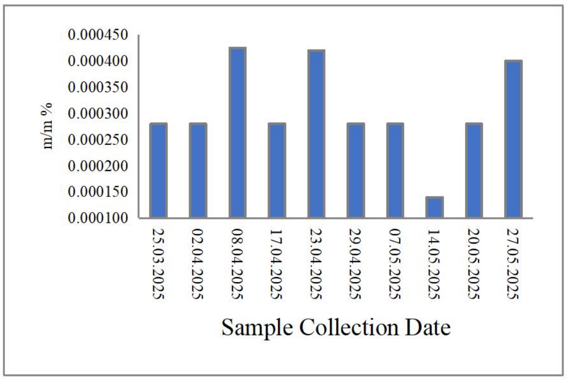

Figure 2 - Results for testing for Chloride Content

Washed and sieved offshore sand samples with varying chloride levels were collected in the period March to May 2025 with a low range of 0.000140 m/m% and a high range of 0.000425 m/m% (Figure 2). On 08.04.2025 the highest value was 0.000425 m/m%, whereas on 14.05.2025 the lowest value was 0.000140 m/m% obtained. Every recorded concentration is far beneath recommended 0.01 m/m% allowable limit outlined in SLS 1397 and thus tested sand can be used in construction and structural engineering applications.

The continually low measures indicate that washing and sieving application effectively eliminated soluble Chloride salts that are typically accessible in offshore sand caused by the exposure to seawater. Because high chloride content of the sand may lead to faster reinforcement corrosion and reduce the structural durability, there is a significant concern over standards compliance. These results prove that the type of examined offshore sand is suitable to be utilized in construction projects in case the requirements of appropriate washing and handling of material are adhered.

With regards to the environment, the application of offshore sand with a controlled chloride level is beneficial in reducing river sand mining which protects the river ecosystem, biodiversity and also natural water flows and guarantees the sustainability of construction practices in the long run.

2. *Testing for Acid Soluble Sulphates*

Following results were obtained for the testing of acid soluble sulphates content in the washed and sieved offshore sand sample.

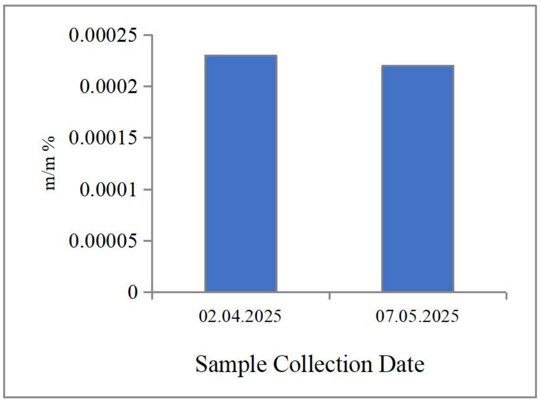

Figure 3 - Results for Acid soluble Sulphates of offshore sand

Samples were analyzed in terms of acid soluble sulphate content of washed and sieved offshore sand. As shown in Figure 3, the results obtained were 0.00023 m/m% and 0.00022 m/m%. All values were well below the maximum allowable value of 0.2 m/m% stated in SLS 1397 thus providing factual evidence that the tested offshore sand falls within the acceptable range in terms of its quality to be used in construction. Low levels of sulphates show that the washing and sieving procedure succeeded in limiting soluble salts which in most cases are added during the long contact with the seawater.

Concrete cracking due to the formation of expansive products like gypsum and ettringite (delayed ettringite formation), which contain high sulphate concentrations in sand, can cause reduction in durability. It is shown in the results that the offshore sand under test is safe in respect to sulphate attack or not a major hazard or threat and can be used on reinforced and plain concrete works with a regular course of utmost caution and quality control.

Controlled levels of sulphates of the environment guarantee sustainability of construction, diminish the use of river sand mining, safeguard the aquatic ecosystems, and maintain the material durability and the long run safety of infrastructure.

3. Testing for Total Sulphur Content

Following results were obtained for the testing of total Sulphur content in the washed and sieved offshore sand sample.

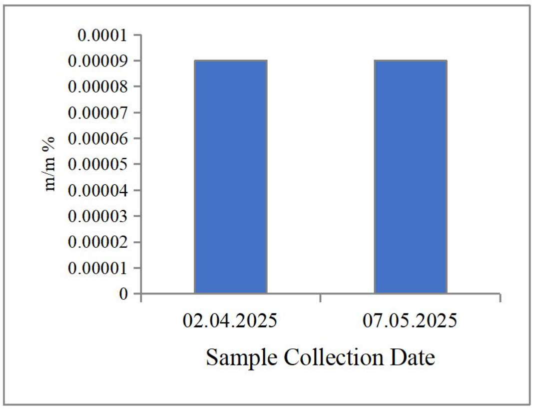

Figure 4 - Total Sulphur content of offshore sand

Washed and sieved 02.04.2025 and 07.05.2025 of offshore sand material showed a corresponding data of the total Sulphur content as 0.00009 m/m% (Figure 4). These respective values are much lower than the maximum permissible limit of 1 m/m% as specified in SLS 1397 and it re-confirms that the material is within the required standard. There is also very low Sulphur content which means that washing removes Sulphur bearing contents like Sulphides and Sulphates which are common in marine sands due to exposure of the sand to seawater and the presence of organic needs. There is also risk of such excessive Sulphur in sand resulting in development of harmful substances, like Sulphuric acid or expansive Sulphate salts, which can result in destruction of cement paste and corrosion of reinforcement in concrete. The use of both sampling rounds, low results in both rounds indicate high standards of quality control and devoid of any environmental impact and thus the suitability of the tested offshore sand to be used in concrete and structural construction purposes.

The low sulphur decreases the risk of the concrete deterioration and corrosion of the reinforcement. Its environmental benefits include sustainable usage of offshore sand, which contributes to the preservation of ecosystems of rivers and guarantees structural security of construction in the long term.

DISCUSSION & CONCLUSION

The analysis of washed and sieved offshore sand in relation to chloride, acid soluble sulphates and total sulphur content shows all of the quantities measured were below the maximum recommended standards as per standard SLS 1397. This proves that soluble salts and possibly harmful sulphur compounds are properly washed away by means of proper washing and sieving, which leaves the sand of high grade suitable in building works.

These levels of reactive compounds are consistent and increase the high durability and longevity of reinforced and plain concrete, mitigating the chances of corrosion of reinforcement, as well as structural damage. Not only the high-quality properties of this sand make it applicable to the traditional construction, but it also offers a solid base to the technological innovations in the area of sustainable construction. As an example, it can aid the process of creating environmentally friendly concrete mixes, durable infrastructure, and hi-tech prefabrication methods that focus on durability and cost-saving of resources.

One way of ensuring that SLS specifications are met is by carrying out proper supervision, while washing is controlled and the quality of sand is managed throughout the sand processing stages, which will not only help in the sustainable construction practices, but also in the overall aim of reducing environmental impact. The results highlight the possibility of the washed offshore sand to contribute to environment-friendly engineering solutions and encourage innovative technologies in construction in accordance with the principles of sustainable development.

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