Impacts of Salt Water Intrusion on Construction Aggregates of 'Kalu Ganga' Estuary

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Abstract: 'Kalu Ganga' is one of the main suppliers of river sand (113,360 cubes per year) in the country. Due to the continuation of sand mining, salt water intrusion has been increased over the years. The focus of the current research is to understand impacts of salt water intrusion on river sand and to understand whether the absolute chloride content of mined sand is within permissible level (0.075% Cl^-) for the construction purposes. Two surveys were conducted along 'Kalu Ganga' estuary (10 km from river mouth) in predetermined intervals to measure depth, conductivity profiles and to collect sediments samples. Survey dates (16/12/2008 and 12/03/2009) were selected considering the maximum difference of tide and rain fall. The sand samples were analysed for Cl^- content. Results showed significant salt water intrusion even during dry season (≈2300 µS/cm). All measured conductivity values were similar to the conductivity levels observed at the sea mouth. But during dry season the Cl- content of sediments is relatively high at river mouth. However, during rainy season, measured salt water intrusion levels were dropped down remarkably (≈200 µS/cm) and even at the sea mouth, sediment samples showed significant low values of absolute Cl^- content (0.0176%). Therefore, it is recommended to extract sand from 0.5km from the sea mouth only during rainy season. This will also control the flooding in Kaluthara area. However, further studies are necessary for understanding other environmental effects of river sand mining near the sea mouth.

Keywords: Chloride content, Conductivity profiles, Neap tide, Salinity, Spring tide,

1. Introduction

River sand is an important aggregate in construction industry. As the rapid advancement of the industry, river sand mining has begun to increase in every possible area in the country. Although, alternatives were introduced, the local demand is about 10 million cubes per year. For river sand the demand is not decreasing because of its quality and reliability. Therefore, Kalu Ganga is one of the main suppliers of river sand (≈113,360 cubes/yr) for major construction projects in the country due to the

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closer proximity to Colombo.

Although the sand extraction from Kalu Ganga basin have reached the maximum capacity, sand suppliers are still striving to fulfil the demand with illegal mining and trying to grab the market opportunities. Over the time there were more emphasis on sustainable development of river sand mining and it has been recognized these illegal and unethical sand extractions have massive bad effects on water column like salt water intrusion.

Salt water intrusion can generate a totally different environmental system by long term activity. But when it happens in fresh water streams, it can damage the prevailing system. This problem is happening in Kalu Ganga estuary during dry season. Uncontrolled sand mining of the area pulls up this problem and at present, intruded salt water reaches beyond Kethhena fresh water intake station.

The intruded salt water does not only pollute fresh water but also affects aggregate sand sediments on the bottom of the river by adding more Cl^- ions. When the amount of Chloride ions of sand goes beyond permissible level (0.075%) It becomes unsuitable to be used for construction purposes.

The objectives of the current research is to understand impacts of salt water intrusion on river sand and to understand whether the absolute chloride content of mined sand is within permissible level (0.075% Cl^-) for the construction purposes.

2. Methodology

Two field surveys were conducted to collect sediment samples and conductivity data. Sampling route was selected from river mouth to 10 km upstream as shown in Figure 2.1a.

Figure 1. Location map of two surveys

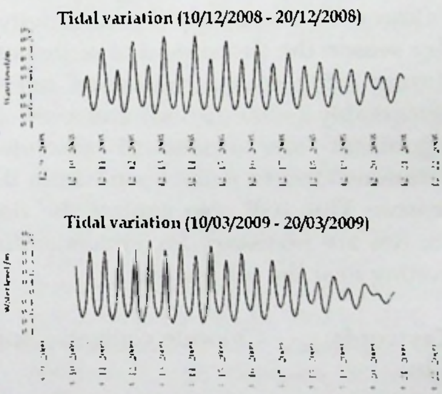

Figure 2. Predicted tide levels on related dates.

Sediment samples were collected from predetermined sampling locations along the sampling route (Figure 1) by using a grab sampler. The vertical conductivity profiles (at 1m interval) were measured for each sampling locations using a CTD (Acteon 3000 water quality profiler). The depth of the river was also measured by using CTD in every sampling location. The two sampling dates (16/12/2008 and 12/03/2009) were selected considering the maximum difference of the tidal variation and rain fall as shown in Figure 2.

2.1 Sample analysis

Vertical conductivity profile graphs were plotted from collected data for every location and hence the depth variations along the sampling route and the longitudinal depth profile of Kalu Ganga estuary were obtained. Sieve analysis was done for collected sand samples of each locations using standard sieve set for Cl^- content (BS 1377: Part 3: 1993).

3. Results

Salt water intrusion was significant during dry season with spring tide and all the conductivity levels were similar to that of at the sea mouth (≈2300 μS/cm). During rainy season together with spring tide, remarkable low salt water intrusion values were observed (≈200 μS/cm).

Sieve analysis showed that the bottom sediments consist of well sorted sand fraction and similar conditions prevailed almost every location of the survey path (mostly in sand mining area, 3-7 km).

Depth profiling (Figure3) shows a sandbar formation near river mouth (1-3kms) during dry season. Then suddenly the depths get lowered due to heavy sand mining during dry season.

The depth profile and $Cl^-\%$ variation along the survey path clearly show (Figure3. and Figure 4) the relationship between lowering of river bed and Cl^- contamination during dry season.

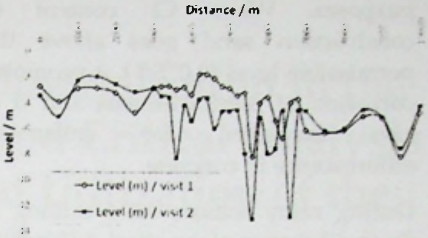

Figure 3. Comparison of depth profiles along the route on two survey dates (visit1-16/12/2008 and visit2 - 12/03/2009).

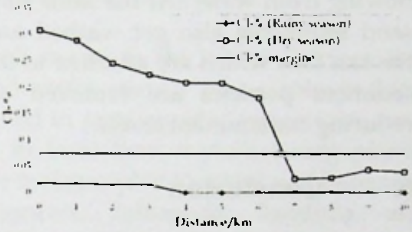

Figure 4. Comparison of Cl^- % variation along the river during the rainy season and dry season, and the deviation from permissible level.

5. Discussion

According to the study, people usually mine river sand illegally in Kalu Ganga basin especially during dry season. Hence the uncontrolled sand extraction directly contributes to lower the river bottom starting from 3km upstream of the river mouth. This increases the effect of salt water intrusion in the area examined. The intruded salt water moves upstream a long distance along the river and remains in place due to its high density and low momentum of the fresh water system in dry season.

As a result of intruded high dense salt water, the bottom sand sediments get contaminated with various salt ions like Chloride and it reduces the quality of the aggregate sand for construction purposes. When Cl^- content of construction sand goes above the permissible level (0.075%), it promotes corrosion of reinforcements and it is also suspected for enhancing efflorescence in concrete.

During rainy season, sand mining is limited because of practical difficulties of miners since river currents prevent the access of minable areas. During this period of time, intruded salt water is flushed off by high turbulence and high momentum caused by down flowing fresh water. At the same time sand sediments also get washed and the salt ions which are attached to the sediment particles are removed off reducing contaminant levels.

6. Conclusion

Sand mining in Kalu Ganga estuary area directly causes to increase salt water intrusion in dry season. River sand which was extracted with in 1st 7km from river mouth shows high Cl^- content. Therefore it is not suitable for construction purposes during dry season. In rainy season there were no significant salt water intrusion and no significant Cl^- contamination in sampled locations during the study period.

Therefore it is suggested that the sand mining of the area should be performed more during in the rainy season and should restrict to the 1st 7 kms during the dry season.

Sand mined during the rainy season near the river mouth could be used for construction purposes without any processing. Therefore sand mining can be started almost at the river mouth during rainy season. Well monitored sand mining during the rainy season will also be helpful to reduce flooding in up stream, trapping of salt water inside the river and other related side effects on the environment.

However, further detailed studies are necessary for understanding other environmental effects of river sand mining near the sea mouth even in rainy season.

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