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Challenges in Developing a Sustainable Dredging Strategy

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Abstract

Sustainability issues are of growing concern in the world, as the effects of human activities on the planet become more visible. The environmental impact of dredging activities has been a point of discussion for a long period. Over recent years more emphasis is put on sustainability by different stakeholders in answer to the climate change effects like pollution, shortage of resources , stress on ecosystems and as a result an imbalance in the total system. It is our task to combine sustainability requirements with the ever increasing demands on dredging applications. To date, dredging equipment has been designed from an economical point of view. The social balance is more or less easily attained depending on the situation. . This paper will evaluate the challenges to develop a sustainable dredging design philosophy with ecological requirements, without compromising economy.

***Keywords**:* dredging; sustainability; climate change; challenges

1. Introduction

Dredging is an activity that is required to be carried out to remove the unnecessary deposits from water pathways. But even though the activity aids regularity in marine traffic, it is not without its disadvantages. Dredging possess a huge threat to the marine environment and is required to be carried out quite carefully aided only with the help of the right dredgers and dredges.

Significant effects of dredging on the marine environment include effects of the dredging process and disposal process. The dredging site undergoes biological, physical and chemical impacts. Dredged material may cause suspended solids during dredging as a result of substratum disturbance and during transport to the surface, overflow from barges or leakage from pipelines during transport between dredged and disposal sites. Dredging may affect the physical environment by changing the bathymetry, current velocity and wave conditions [1]. Light attenuation by suspended sediments affects the amount of light

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available to sea grass plants and several marine organisms. Turbidity should not only be expressed in terms of a reduction of light but also by investigation of suspended solid concentrations [2]. The turbidness of the soil under the water also changes because of this alteration in the underwater soil composition. This poses problems by way of creation of newer and harmful organisms, transferring of unwanted organisms to other parts in the water-body leading to a wider spread of contamination and organic processes by way of release of extra and unwanted nutrients. The turbidness also causes the already existing contaminations to spread further into the water-body which also affects the marine environment adversely.

Since dredging loosens up the soil, those substances which were previously held fast to the contaminated deposit will find their way into the water and the un-dredged soil. If these substances are harmful organisms then they will cause a substantial degradation to the environment even after dredging the area. To ensure that the process of dredging is carried out without any debilitating effects, it is important to use the right dredgers. As an example, the trailing suction hopper dredgers that suction out the deposits are considered to be a major cause for turbidness in the dredged water-part. It has been recommended that those dredgers which present a chance for pollution and extensive contamination be avoided and replaced with other safer methodologies.

In this paper, the environmental impacts of dredging and major challenges for sustainable dredging at Jamuna river of Bangladesh are presented as a case study.

2. Case Study

Bangladesh government has undertaken a mega project named “Capital Dredging of River System of Bangladesh”. One of the major Location of dredging is Jamuna River from upstream of Sirajganj Hard Point (through Bangabandhu Bridge) to near Dhaleswari Offtake [figure-1]: to divert the flow from the west channel into a mid-channel to reduce the risk of failure of Sirajganj Hard Point and to guide the flow along the middle of the existing char through the Bangabandhu Bridge to near Dhaleswari Offtake. [3]

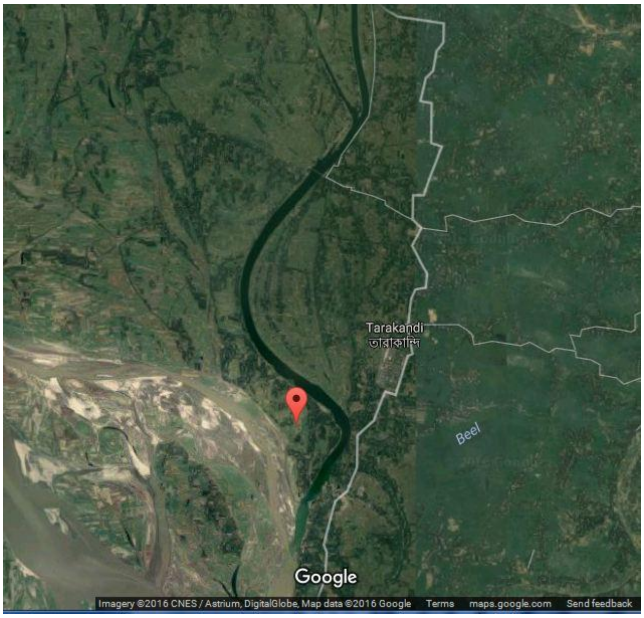

Figure 1: Map for the site showing the proposed dredging zone of Jamuna river

It will reduce the risk of riverbed scour along the Sirajganj hard point and also reduce the erosion of right guide bundh of Bangabandhu Bridge [4]. 192.42 kilometres of river have been already dredged. It includes test dredging in 22 kilometre areas of river Jamuna River. Four cross bars have been developed adjacent to Sirajganj town by the dredged materials and about 16 Square kilometres of land have permanently been recovered. 1, 4792 hectares of land have been settled among 17,533 landless families under the settlement and development projects in the coastal strips [5]. Water level hydrograph of Sirajganj season has shown in the figure-2 [6].

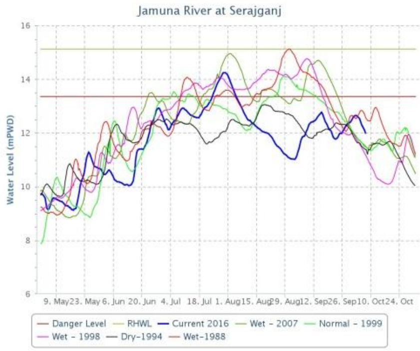

Figure 2: Water Level Hydrograph of Sirajganj Point

Another major objective of this capital dredging project is to study for sustainable river management of all the river systems. From an ecological perspective, dredging can have many significant impacts upon river ecosystems and their wildlife. Plant communities can be affected through physical disturbances, alterations in river flow affecting their ecology. Invertebrates and fish can be affected via sediment disturbances and loss of habitat, which can have knock on effects for those higher up the food chain. Those living on river banks, such as water voles, or those on the floodplains themselves, such as wading birds, can also be affected.

3. **Major Challenges in Sustainable Dredging**

3.1 Minimizing turbidity

Almost all types of dredgers cause some turbidity during excavation as well as during the flow of sediments from the hoppers and barges. The plumes seen behind dredgers are evidence of this. The plumes arising from trailing suction hopper dredgers are caused by the discharge of sediment-laden water from the hopper which can form surface or near bed plumes. Disturbance by the drag head and erosion from propeller wash also play a role.

Turbidity seen in the above-mentioned plumes can easily be calculated in the field on site. For the sake of accuracy turbidity during dredging operations should be and can be measured on any spacing of time or even continuous basis depending on the locality. Figure-3 shows the amount of ammonia release during passage of turbid plumes. Turbidity measurements are then an immediate and reliable indicator of marine conditions.

Turbidity could not be removed entirely. Limiting turbidity during a dredging project is obviously possible and monitoring turbidity carefully so that it is more controllable and therefore acceptable is a high priority. A thoroughly thought-out EMP [7] can help foresee challenges and allow for the development of innovative methods to help mitigate impacts. In this way sensitive environments can be protected.

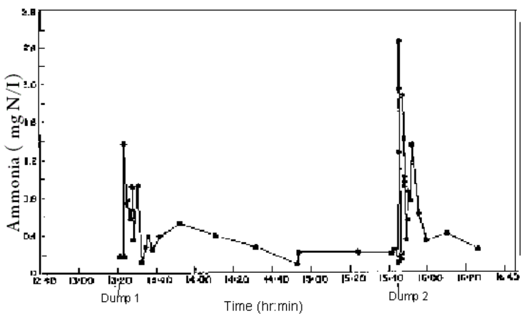

Figure 3 : Ammonia gas release during passage of turbid plumes

3.2 Alternative Energy

Growing environmental awareness and social challenges like air quality, climate change, and energy scarcity have resulted in the latest emissions legislation as set forth in the International IMO and US EPA regulations. Recent legislation covers the emission of NOx (Nitrogen Oxides), SOx (Sulfur Oxides), THC (Total Hydrocarbons) and PM (Particulate Matter) (Figure-4).

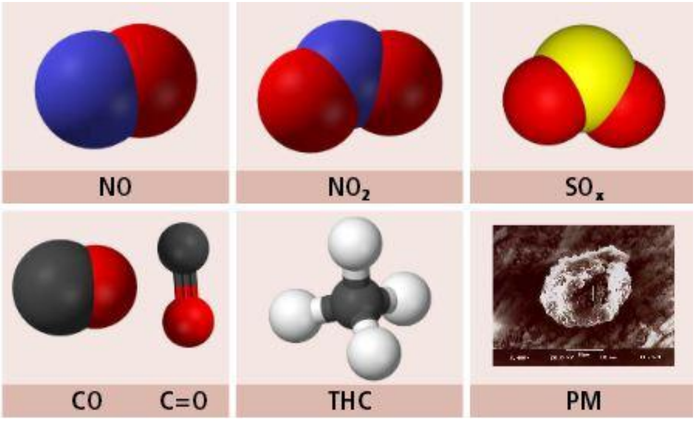

Figure 4: Images of the regulated emissions

Ships use a bit below graded fuels as energy source. On world scale these fuels are merely considered a bi-product of the refinery process. These low grade fuels could be upgraded, albeit at high costs. Primary worldwide energy streams would be disrupted if all ships turned to other, hydrocarbon based, energy sources such as light distillates. As a result, stakeholders accepted, until recently, the disadvantageous harmful emissions in the exhaust gases of the ships' prime movers that resulted from use of these lower grade fuels in April 2008, a new text of Marpol Annex VI was agreed upon by the IMO's Marine Environmental Protection Committee in London [8]. Implementation of this legislation will have a dominating impact on the development of propulsion systems in the near future. Annex VI demands a significant reduction of the emissions of Nitrogen Oxides and Sulphur Oxides.

Synthetic fuels might be an option for shipping, but a solution of this kind should come from the oil industry and chemical industry. If this possibility emerges, different stakeholder will certainly consider this possibility. LNG [9] is certainly a potential solution, particularly on short sea shipping. Gas production is much higher than gas consumption, and the excess production is more than sufficient to supply all ships with energy. For energy conversion we could use either a dual-fuel diesel-engine, or a gas turbine. Especially the latter solution has a very high power density, saving space and weight. Disadvantages are the space requirements of the gas tanks and the strict requirements imposed on such ship by the authorities. Batteries are a potential solution, but at this moment far too expensive and too heavy to be a feasible alternative. Fuel cells may form an alternative in the future. At this moment, the largest available units provide about 30 kW. In the future, we could consider fuel cells as alternative for auxiliary or port generators. Wind energy could be an option for auxiliary too. As main energy source, wind energy is not a feasible option. A large wind mill produces about 1000 kW of power. About 20 large wind mills are required to supply energy to a large dredger. As auxiliary energy source for remotely located consumers, small windmills could be an option. Solar cells currently produce too little energy per square meter (approximately 130 W/m2). Current generation solar cells could only be used for small, remotely located consumers. Contrary to wind mills, solar cells may be strongly improved in the future. This would make solar cells a potential auxiliary energy source. Finally, bio fuels are subject to a lot of discussion at this moment.

3.3 Shortcomings of the NOx legislation

The NOx emission legislation [10] dictates a low emission from the exhaust pipe of vessels. This emission reduction can only be solved partly by internal engine modifications. As a result of the lower combustion temperatures imposed, the required reductions of emissions to comply with Tier II were attained to the detriment of lower engine efficiency (about 5%). Further reduction as required to comply with Tier III legislation (which is 80% lower than Tier I), requires a post-combustion treatment system. The SCR technology [11] seems to be the best established technology by now. However such a system does not run for free on board vessels. Internal feasibility studies indicate that the lower combustion temperature, additional equipment and increased exhaust back-pressure add up to 10% higher fuel consumption compared to Tier I.

4. **Sustainability in Dredger**

4.1 Hull design

The shape and size of the hull influences the wave pattern of the ship which finally influences the energy consumption of a vessel at a given sailing speed. This new bulbous bow design, which reduces wave-making resistance, can be seen in Figure 5.

Figure 5: A view of the innovative bulbous bow design, which reduces wave-making resistance

In Figure 6 two almost similar ships are shown. The only difference between both ships is the shape of the hull. As can be seen in the pictures, the ship on the left has a significant higher bow crest. In practice this resulted in a difference of 25% more fuel consumption during sailing than in the ship

Figure 6: Left, the traditional hull shape; right, the improved bulbous hull resulting reduced fuel Consumption

4.2 Pump Design

For a long time pump designs have evolved significantly. In the late 1990s a first step was made to increase efficiencies from 85% up to 95%. In practice this leads to an enormous reduction in emissions per m^3 or $yd^3$of dredged material. With modern tools such as CFD, pumps can be optimized to have a good balance between efficiency, sphere passage, but also suction properties. An example is the cutter special pump shown in Figure 7, combining these properties.

Figure 7: cutter special pump provides a good balance between efficiency, sphere passage

4.3 Automation of Dredger

With the introduction of contemporary drive trains, also a wide range of automation and control systems have been introduced over the past years. Control systems have made it possible to perform relatively complex dredge projects. Interesting examples are the Dynamic Positioning and Dynamic Tracking systems [12] which made highly accurate dredging with hopper dredgers possible. These automation systems also introduced possibilities to reduce fuel consumption as such as production optimization with automatic pump controllers and automatic cutter controllers.

5. **Summary and Conclusions**

A range of solutions for sustainable dredging exist and an assessment of these options often proves to be challenging for decision makers. Every single challenge requires an extension of our spatial and temporal horizons to look to the consequences of decisions and actions into the future and upon contemporary communities living further afield.

The major finding of this study is that the major challenges of sustainable dredging are turbidity and alternative energy. It is also observed that, if the dredging equipment design modified a bit then the dredged channel would be more sustainable.

The degree of the impacts of dredging depends on the extent of the areas dredged, the frequency and duration of dredging activities, the characteristics and the sensitivity of the areas dredged and their surroundings, the dredging techniques applied as well as relationships with other uses and users of the system . Hydrodynamic and side cast techniques raise the turbidity on the dredging sites potentially more than conventional dredging techniques. These techniques use the principle of deliberate re-suspension of the fine fraction of sediment from the riverbed or seabed with the aim of removing this material from the dredging area using natural processes for transportation.

A higher sustainability in the dredging project can be reached technically by optimizing the dredger as well as by proper operation and project management. Different shipbuilders are continuously developing cleaner alternatives and more efficient dredging, mining and offshore applications for addressing the challenges of a clean and lean dredging process in the future. They also actively participate in the development of legislation and standards in order to contribute to a global level-playing balance between technology and sustainability that truly benefits nature and humans.

6. Acknowledgement

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