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A Review of Environmental Implications of Dredging Activities

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Abstract*—Dredging is a global anthropogenic excavation activity of removing sediments from water bodies and depositing it elsewhere. It is a mixed blessing as it has both beneficial and adverse impacts. This paper is on a review of environmental implications of dredging. The objective of the paper is to review previous works by researchers on the environmental consequences of dredging. The method used is a review of academic/journal articles, internet materials, conference / workshop papers, textbooks, bulletins and publicly available materials on dredging activities. The results of the study revealed that previous authors whose works were reviewed have a convergent view that apart from the beneficial impacts of dredging (e.g. keeping waterways navigable, flood and storm protection and provision of materials for road construction and building), it has lots of adverse environmental impacts, including environmental pollution, erosion, widespread hydrological changes, reduction in the population of aquatic lives like destruction of fish spawning grounds and benthic organisms and resuspension of particulate matter column that has elevated levels of lead, copper, zinc and nickel in Phytoplankton. Recommendations of the study include: (1) establishment of environmental legislations and regulations for dredging operation; (2) use of green technology in dredging activities to minimize suspension of sediments and contamination/pollution of dredging environments; and (3) creation of awareness among dredging contractors, regulators and marine communities where dredging take place on the economic and ecological values of the marine ecosystems that are usually very sensitive, fragile and productive.*

Keywords— Dredging, Environmental Implications, Marine Ecosystems, Review Sediment, Sustainable Development.

I. INTRODUCTION

Dredging is a worldwide excavation activity that involves removing sediment from a sea, river, or lakebed and depositing it at a new location (Brunn, Gayes, and Eiser, 2005; Thomsen, McCully, Wood, Pace and White, 2009). They further reported that uses of dredged materials are vast and include construction of ports, waterways, dykes, and other marine infrastructure, land reclamation, flood and storm protection, extraction of the construction industry (e.g for road construction and buildings) and in environmental remediation of contaminated sediments. International Association of Dredging Company (IADC) (2012) opined that population growth and increasing number and size of infrastructure projects mean that demand for dredging, volume of aggregate, and turnover will most likely increase. Since dredging impacts the marine environment, sustainable management of the activity is required, based on in-depth understanding of how dredging affects marine habitats and associated fauna and flora (Thrush and Dayton, 2002; David, Hitchcock and Bell ,2004; Erftemeijer and Lewis, 2006).

Globally, dredging activities certainly affect the global economy and in fact still plays a huge role in global trade (Bob, 2015). IADC (2012), reported an estimated 11.68 billion of dredging work. In Nigeria, dredging activities are a major environmental problem (Abubaker, Alzubi and Alzyond, 2011). They further noted that mining industries and dredging practices in particular are vastly known for their hazardous working condition and the unstable nature of the earth-crust which minerals are extracted is causing threat to life and properties of the society. According to Robbins (2006), dredging is an excavation activity of operations usually carried out at least partly under water, in shallow seas or fresh water areas with purpose of gathering up bottom sediments and disposing them at a different location. He further asserted that dredging helps to keep waterway navigable, and also a way of replenishing sand on some public beaches, where sand has been lost because of coastal erosion.

Walker, Hillman, Kendrick and Lavery (2001) defined dredging as an activity that is done or carried out using a device, machine or vessel that is used to excavate and remove materials from the bottom of a body of water, for example, a scoop is attached to the rope or pole by which a man can draw sediments up from the bottom of a pond, or river. In the view of Watson, Revenga and Kura (2006), dredging involves the excavation and relocation of sediments from lakes, rivers, estuaries or seabed and is a critical component of most major marine infrastructure development along the coast. Despite the necessity of

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dredging for industrial development, its potential impacts on the environment are particular concern as multiple potential stressors associated with dredging activities are sediment stress (suspended and deposited), release of toxic contaminants, hydraulic entrainment and noise pollution (Reine, Clerk and Dickerson, 2014; McCook, Schaffelke, Erftemeijer and Warne, 2015). The process of dredging creates spoils (excess materials), which are carried away from the dredging area; dredging can create disturbance in aquatic ecosystem after with adverse impacts (Bertha, 2009). He further claimed that dredging can create much effect on land. Dredging has a number of undesirable geomorphic consequences, showing the vertical incision and bank destabilization can occur from dredging activities (Mmom and Chukwu-Okeah, 2012).

1.1 Statement of the Problem

Dredging has created a lot of problems and these include change in the aquatic ecosystem, environmental pollution, flooding of coastal land and erosion, infrastructural damage, flooding of coastal land and reduction in the population of aquatic lives useful to man (Fortes, 2001). He further reported that dredging activities often disturb sediments reducing visibility and smothering reef organisms. Ohimain and Van Mensvoort (2004) asserted that dredging has been associated with widespread hydrological changes as it may disrupt the dynamic interrelationship between environmental components and socio-economic functions of these coastal areas, thus creating an imbalance in the ecosystem. The extent at which dredging occurs in rivers, lakes, ponds, coastal regions is becoming a treat (IADC) (2012). Environmental Protection Agency (EPA) (2013) reported that dredging activities has potential to change the environment, as well as toxicant, the nutrients (elements), particularly nitrogen and phosphorus which control the rate of marine plant growth, can be released from sediments during dredging with a risk of triggering algae blooms. Dredging activities potentially affect not only the site itself, but also surrounding areas, through a large number of impact factors such as turbidity, sedimentation, resuspension and release of contaminants effects can be immediate or develop over a longer time frame and they may be temporary or permanent in nature (Wolanski and Gibbs, 2004).

1.2. Objective of the Study

The objective of this paper is to review environmental implications of dredging activities.

II. CONCEPTUAL FRAMEWORK: SUSTAINABLE DEVELOPMENT

This paper adopts the concept of sustainable development as its framework. The World Conference on Environment and Development (WCED) (1987) defined sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Morelli and Greenwood (2010) claimed that sustainable development is meeting the resource and service needs for current and future generations without compromising the health of the ecosystems that provide them and more specifically as a condition of balance, residence and interconnection that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs by our actions diminishing biological diversity.

This study is focused on a review of the environmental implications of dredging so as to build in sustainability into the management of the phenomenon.

III. METHOD

This research made use of a review of academic articles, journals, internet materials, textbooks, conference papers and publicly available materials on dredging activities. The researchers assembled thirty of these materials for this research, but summarized the characteristics of 10 deemed more relevant to environmental implications of dredging for the review. This enabled the researchers to make a synthesis of various researchers' views on implications of dredging activities.

IV. REVIEW OF RELATED LITERATURE

Watson, Ravenga and Kura (2006) conducted a study on Trawling and Dredging in Western Australia and asserted that dredging involves the excavation and relocation of sediment from lakes, rivers, estuaries or seabed and is a critical component of most major marine infrastructure development along the coast. Hitchcock and Bell (2004) carried out a study on marine aggregate dredging in Florida and reported that sediment plumes cannot be under estimated as it is a phenomenon that has the capacity to extend the footprint of impact beyond the limits of the dredging activity itself. Copper, Curtis, Hussain, Barrio Fajon, Defew and Nye (2011) studied implications of dredging in United Kingdom and claimed that changes in sediment composition can have implications for residents and recolonizing fauna, resulting in the establishment of fauna community that differs from the assemblage present before the dredging. They also asserted that marine aggregate dredging is to identify those locations where it is more and less important to try to preserve sediment particle size composition, and to determine whether there is a rational scientific justification for the active restoration of sediment particle size composition at site of former marine aggregate dredging.

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In their study on impact of dredging seagrassses in the Netherlands, Erftemeijer and Lewis (2006) reported that dredging and disposal of dredged materials can lead a temporary decrease in water transparency, increased concentrations of suspended matter and increased rates of sedimentation. They also opined that impacts can be significant when dredging or disposal is done in the vicinity of sensitive marine environments, such as coral reefs and sea grass bed. Cooper, Boyd, Eggleton, Limpenny, Rees and Vanstaen (2007), in their study on marine aggregate dredging in England, and asserted that deposition of sediment from plums created during dredging operations will likely inhibit recovery of benthic communities. Wilber and Clarke (2001) did a research on suspended sediment in Charleston and noted that dredging released nutrients that led to depletion of oxygen from high phytoplankton production. Michael, Woodley, Todd and David (2015) conducted a study on suspended sediment in Vicksburg and claimed that river channel maintenance relies on frequent dredging to keep the water ways navigable. Nayar, Miller, Hunt and Goh (2007) were of the view that dredging of channel and excavation of the banks exposed the underlying layer of historically contaminated sediments, compromising partially decomposed organic matter from dredging activities, resuspension of sediment partially accounted for higher concentrations of organic carbon in water column, in their study on impacts of dredging in Singapore. A research by Nayar, Goh and Chou (2004) on heavy metals from dredging in Singapore revealed that dredging operations potentially released toxins into the marine environment. They further claimed that in Zeebrugge and Singapore dredging, operations led to resuspension of particulate matter column that has elevated levels of lead, copper, zinc and nickel recorded in phytoplankton.

Walker, Hillman, Kendrick and Lavery (2001) researched on ecological significance of dredging in Western Australia and asserted that dredging in shallow near-shore waters associated with significant conservation values, adverse effects on marine habitats due to direct seabed disturbance and indirect effects could offset shipping movements and seabed shoreline stability. A research by Desprez (2000) on impact of marine aggregate dredging in France indicated that extraction of marine aggregate has its impact on the seabed as dredging activity has conventionally targeted bottom substrate associated with benthic fauna. Mmom and Chukwu-Okeah (2012), in their study on sand dredging in Calabar, opined that increasing anthropogenic disturbances have imposed considerable impacts on river channel. They further reported that high dredging activities had resulted to serious incision of the river channel deepening the river bed and increasing velocity of flow. Rinaldi, Wyzga and Surian (2005) conducted a study on sediment mining in Italy and claimed that channel incision of alluvial river as a result of sediment depletion arising from dredging had series of detrimental effects on the river channel, including ground water table lowering, flood flow increase, the destabilization of infrastructures, sea water encroachment in the area. Michael *et al* (2015) carried out a research on potential dredging impact in Vicksburg and reported that dredging is a complex activity, and its impact on aquatic ecosystems is poorly understood, over long-time scales. Muyideen, Abiodun and Ismaila (2013), in their study on impacts of dredging in Awoyaya Lagos, claimed that dredging activity pollutes the environment and the water source of the area, thereby endangering the life of people and aquatic animal in the area.

Table.1: Summary of Characteristic of some Studies on Environmental Implications of Dredging Activities.

S/N	***Author(s)***	***Topic of Research***	***Method(s)***	***Results***	***Recommendations***	***Conclusion***
1	Cooper, Curtis, Hussian, Barrio frojan, Defew, Nye and Paterson (2011).	Implications of Dredging Induced Changes in Sediment Particle Size Composition for the structure and function of marine benthic macro-faunal communities.	-Physical Observation -Laboratory analysis	The result suggested that the presence of gravel has an important role in the negative correlation in sediment composition of natural physical disturbance.	License enforcement should be put in place regarding changes in sediment composition.	Changes in sediment composition in the area are likely to have a reduced impact on the overall faunal assemblage, possibility and measurable in sediment composition.
2	Copper, Boyd, Eggleton, Limpenny, Rees and Vanstae (2007).	Recovery of the Seabed Following Marine Aggregate Dredging on the Hastings Shingle Bank Off the	-Site Observation -Laboratory Analysis.	The result from both sites provides a useful in-sight of the processes leading to recovery of the	Caution in assuring recovery figure should be applicable to intensively dredged areas.	A comparison of recent and historic dredged track features provided evidence of track

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S/N	*Author(s)*	*Topic of Research*	*Method(s)*	*Results*	*Recommendations*	*Conclusion*
		South-east Coast of England.		seabed marine aggregate dredging at the site.		erosion.
3	David, Hitchcock and Bell (2004).	Physical Impacts of Marine Aggregate Dredging on Seabed, Resources in Coastal Deposits.	-Survey Strategy	The result reported that the geological conditions are more likely to result from dredging disturbance.	Deep-water extensive operations with screening of cargoes should be avoided.	It is clear that development of linear down tide extension near bed sediment plume provides a mechanism for potential impacts in areas where screening cargoes takes place.
4	Muyidean, Abiodun, and Ismaila (2013).	Environmental Impacts of Dredging in Awoyaya, Lagos State, Nigeria.	-Laboratory analysis -Physical Observation.	Water is acidic and soil has a very high percentage of silica.	Disturbance arising from dredging operation should be controlled and standards should be set to decrease disturbance of dredging operation.	The analysis carried out shows that dredging in Awoyaya has little impact on water and soil in the dredging area.
5	Mmon, and Chukwu-okeah (2011).	Sand Dredging and River Morphology Change Along Parts of New Calabar river in Akpor Area of Rivers State, Nigeria and its implication for Biological resources conservation.	-Laboratory Analysis -Physical Observation.	The high dredging activities in the area has resulted to serious incision of the river channel thereby deepening the river bed and increasing the velocity of flow.	Proper checking of dredging activities along the river course to protect the environment and biodiversity from net loss or decimation.	The dramatic river bed down-cutting as a result of sediment depletion has important implication for river management of the rivers.
6	Nayar, Miller, Hunt, Goh, and Chou (2007).	Environmental Effects of Dredging on Nutrients, Carbon and Granulometry in a tropical Estuary	-Laboratory analysis	The mean and range for nutrient concentrations showed relatively elevated levels post dredging were positively and significantly correlated with sand fraction.	Monitoring study should be used for effective management strategy to protect the environment.	The most obvious impact of the anthropogenic activities in tropical estuary was the bioavailability and dispersion of nutrients.
7	Nayar, Goh, and Chou (2004).	Environmental Impact of Heavy Metals from Dredged and Re-Suspended Sediments on Phytoplankton and Bacteria Assessed in In-situ Mesocosms.	-Site Observation -Laboratory analysis	The study revealed some high concentrations of heavy metals in suspended particulates and sediments in water level.	Mesocosms should be used for testing since it is very sensitive and reliable for modest investment.	Phytoplankton was inhibited, concentration of heavy metals that were available from sediment re-suspended by dredging.
8	Walker, Hillman,	Ecological Significance of Sea	-Laboratory analysis	Differences between sea	Parameters should be represented by a	The synthesis of these

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S/N	*Author(s)*	*Topic of Research*	*Method(s)*	*Results*	*Recommendations*	*Conclusion*
	Kendrick, and Lavery (2001).	grasses: Assessment or Management of Environmental in Western Australia.	-Physical observation	grass habitats are less pronounced in terms of species presents.	probability distribution with values around the mean valve.	muilt-disciplinary studies has required the development of new techniques to deal with stochastic processes.
9	Watson, Revenga and Kura (2006).	Fishing Gear associated with Global II. Trends in Trawling and Dredging.	Literature review	Composition of trawl and dredged catch is quite diverse.	Analysis should be extremely valuable to inform policy development and to help develop future management options.	Dredging usually associated with the catch of bivalves often peaked later than trawling had decline in most areas.

Source: Researchers' design, 2017.

V. RESULTS AND DISCUSSION

Dredging activities have a lot of environmental implications. From Table 1, Nayar, Goh and Chou (2004) and Nayar *et al* (2007) are of the convergent view that resuspension of sediment partially accounted for higher concentrations of organic carbon, as dredging activity potentially release toxins into the marine environment. Mmom and Chukwu-okeah (2012) and Rinaldi *et al* (2005) were of the view that dredging activities have resulted to serious incision of river channel including ground water table lowering, flood flow increase, destabilization of infrastructures and sea water encroachment in the area. Muyideenn *et al (*2013) asserted that dredging activity pollutes the environment and water source of the area as well endangering the life of people and aquatic animal in the area. Michael *et al* (2015) reported that dredging is a complex activity which has impact on aquatic ecosystem over long-time scales. They were of the divergent view that dredging is done to maintain water ways navigable.

David, Hitchcock and Bell (2004) reported that dredging disturbance will likely result to geological conditions. Mmom and Chukwu-Okeah (2011) deduced that high dredging activities have resulted to serious incision of river channel, deepening the river bed and increasing the velocity of flow. Generally, dredging activities have a lot of environmental implications that tend to pollute the environment as well as endangering life of people and aquatic animals. For example, in Zeebrugge and Singapore dredging operations led to resuspension of particulate matter column in phytoplankton (Nayar, Goh and Chou, 2004).

VI. RECOMMENDATIONS

From the results of this study, the following recommendations are hereby made:

1. Environmental legislations and regulations should be established to monitor dredging operations to reduce adverse environmental impacts.
2. The use of suitable dredging equipment should be encouraged in other to minimize suspension of sediments and contaminants at dredging sites.
3. Efforts should be made to create awareness among dredging contractors and regulatory bodies on the economic and ecological values of the marine ecosystem which are usually very sensitive, fragile and productive.
4. Disturbance arising from dredging operation should be controlled and standard should be set to decrease disturbance of dredging operations.

VII. CONCLUSION

This paper discussed environmental implications of dredging activities through a review of works of pervious authors. Generally, the authors agreed that dredging is the excavation and relocation of sediment from river, lakes, estuaries and seabed. Dredging activities potentially because disturbance to aquatic ecosystem, changes in topography by creation of spoils, short term increase in turbidity which can affect aquatic species metabolism, environmental pollution and flooding of coastal areas and erosion. This study therefore, concludes that although dredging is beneficial in socio-economic terms, its adverse environmental consequences call for proper management to avoid a situation where they undermine the positive impacts.

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