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Impacts related to sand dredging activity: Literature review

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Abstract

Sand is a crucial resource for the development of a nation. It is the second most consumed natural resource in the world after water: humanity swallows 15 billion tons of it every year. This article presents a synthesis of current knowledge on the various impacts related to its exploitation, which is constantly increasing in the world today. The methodology used is based on documentary research and consisted in the analysis of scientific publications, thesis and books on the activity of sand dredging and its impacts. Several works focused on the bio-ecological and socio-economic impacts of this activity on aquatic ecosystems. These studies cover more than 98% of the work carried out in the marine environment. A research orientation aimed at exploring these issues in the lagoon and estuarine ecosystems of southern Benin would contribute to safeguarding the environment and conserving biodiversity.

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Introduction

Sand dredging has become a fairly common practice in many countries in recent years. In some areas it is the main source of aggregates for concrete, public works and beach nourishment (Cooper *et al.*, 2007). In 2009, the volume of sand dredged in France (metropolitan France and overseas, excluding French Guiana) represented a total of 33.58 million tones. The seven major seaports (Dunkirk, Le Havre, Rouen, Nantes, La Rochelle, Bordeaux, Marseille) alone accounted for 88% of the total with 29.6 million tones. In Africa, and more specifically in Morocco, the sand dredging activity reached a turning point in 2007 with the privatization of a single dredging operator, which then aimed at the commercial exploitation of aggregate from the continental shelf (Hakkou *et al.*, 2015). Since then, this activity has raised several issues due to its numerous impacts on the socio-economic, ecological and environmental dimensions, in a universal context marked by climate change, the monitoring and assessment of which are not yet understood, at least as far as the impacts on coastal areas are concerned.

In Benin, several actions have contributed, since 1992, to raising environmental awareness. These include the development and adoption of an Environmental Action Plan (EAP) and the creation of the Benin Environment Agency. A framework law on the environment was then drafted and an environmental impact assessment procedure was instituted. According to this law, any company wishing to carry out an activity that could have an impact on the environment is required to carry out a prior environmental impact study. This is the case for sand-fluvio-lagoon dredging companies. But these studies are very punctual and superficial. Sometimes even the results are controversial and not very credible. Some scientific studies carried out all over the world and more precisely in certain African countries such as Morocco (Hakkou *et al.*, 2015; Hakkou *et al.*, 2016; Hichour *et al.*, 2012); Cameroon (Ekengoue *et al.*, 2018); Senegal (Cesaraccio *et al.*, 2004) and Benin (Kombieni, 2016) have reported certain discoveries on the subject. Indeed, at the beginning of the 19th century, the international community is convinced of the imminence of major disturbances and the terms environment, protection and better management of the environment and its resources are mentioned (Djossou, 2014 and Kombieni, 2016). The United Nations Environment Programme (UNEP) calls for better environmental governance of the world's sand resources. In the coastal zone of Benin, the exploitation of lagoon sand is today a new activity that occupies several actors around the world's different aquatic ecosystems. The extraction of lagoon and rivers sand and then Ouémé river is therefore part of a logic of exploitation of continental sand deposits in substitution of marine sand to reduce the pressure on African coasts which are confronted with environmental problems. Indeed, the strong demographic pressure on the banks constitutes an environmental threat that deserves greater attention.

This literature review is carried out as a prelude to the work of assessing the ecological and biological impacts of sand extraction in the aquatic lagoon ecosystems of southern Benin.

Materials and methods

The methodology used consisted in consulting documents related to sand exploitation in general and in particular on the activity of sand dredging in continental ecosystems and their impacts. Thus, research was carried out in documentation centers of universities and research centers, public, private and national institutions whose activities are related to the object of the study on the one hand, and on the other hand in scientific search engines such as google scholar, PubMed, Scopus and Researchgate. This has made it possible to browse through the various studies and works carried out in Benin, in the sub-region and in the world on the theme in order to take stock of knowledge on the various impacts of sand extraction. This first stage of collecting scientific documents generated more than 250 documents by considering the combination of the following keywords "sand dredging, dredging and sand exploitation, sand of aquatic ecosystems, dredging and aquatic ecology, dredging and aquatic life, impacts of sand extraction, dredging in continental environments" used in French and English. After a summary analysis of these documents, those that actually rule on the impacts of sand dredging activity in continental aquatic ecosystems (lake, lagoon, river…) and published between 1985 and January 2020 were considered. This procedure resulted in the selection of 82 documents including 46 scientific articles, 9 master's dissertation, 4 thesis, 18 reports and Books, free papers including 4 conference abstract books and 1 magazine.

Sand dredging and variants

Dredging is the removal of material (sand, gravel, etc.) from the bottom of a body of water (river or sea) using a dredge (floating equipment) (Dictionnaire sur Environnement, 2010). According to the French dictionary Educaling (2020), dredging is the action of dragging a dredge or similar device to pick up or clean the bottom of a body of water. It consists of the excavation of soil or alluvium under water (lakes, rivers, streams, watrules, canals, estuaries, marine channels, etc.) (Free encyclopedia consulted February 6, 2020). As sand is loose detrital sediment whose grains are mostly composed of quartz between 1/16 mm and 2 mm, sand dredging is an activity that consists of extracting loose detrital sediment whose grains are mostly composed of quartz between 1/16 mm and 2 mm from the bottom of a body of water.

Depending on the tools or equipment used in sand mining, there are several variants (Adjagbo, 2018), namely:

- Artisanal sand extraction: a dredging technique that is done by hand from the time the sand is removed to loading. It is practiced in bodies of water,
- semi-artisanal sand extraction: the sand is taken with a shovel and is directly loaded into the vehicles engaged in the trenches. It is the form of sand exploitation observed in open quarries on the continent; and
- industrial or modern sand extraction: a form of industrial sand dredging where the operation consists of picking up the bottom of a watercourse and removing the sand with specialized machinery.

History of dredging

From the very beginning of civilization, people, equipment, materials and goods have been transported by fluvial way and sea. Ongoing technological developments and the need to improve profitability led to the construction of larger and more efficient ships. This has led to the need to widen and deepen several rivers and canals, "aquatics highways" so that to provide access to ports. Virtually all major ports in the world have at some point required new dredging known as major dredging to widen and deepen access channels, provide turning basins and reach appropriate water depths along waterside facilities. Modern dredging is only the result of thousands of years of evolution, modifications and improvements.

Since 5000 before Jesus-Christ, the ancient Egyptians tried to control the flow of the Nile by trying to build canals to distribute water to distant places. Each year, the canals had to be cleaned of silt buildup (IADC, 1999). This was one of the first organized dredging techniques. At that time, the Egyptians used too primitive dredging methods (wooden poles and bronze shovels) (IADC, 1999). They attached cloth bags to the ends of the wooden poles and dredged with them along the bottom of the canal (IADC, 1999). However, it was not the Egyptians who made dredging flourish. Indeed, dredging on a floating structure (naval dredging) originated in the eastern Mediterranean. According to (IADC, 1999), solid archaeological evidence proves that the Phoenicians had built artificial harbors in the thirteenth century before Jesus-Christ in Sidon, Tyre and Byblos. Cities which, even today, have kept their original names in Lebanon as well as their ports which are still present with their primitive forms. During this period, dredging technology was stimulated by trade (import and export) and war. The Phoenicians were the first to use a floating platform for dredging. At the center of these barges was a lever system. The lever system consisted of a mast mounted on a tripod and attached to a bucket that was plunged into the water. On the other side of this boom were sturdy men who rotated the boom to remove the sediment from the bottom and place it on the platform (IADC, 1999).

It is also interesting to note that the Phoenicians dredged the moat (Water-filled ditch surrounding a castle) of their sea-built fortresses to reduce access. The Romans were captivated by the technology of naval dredging and were able to carry out major works, well helped by the availability of a large number of slaves. The Romans began using concrete 2000 years before Jesus-Christ. In the year 180 after Jesus-Christ, the Romans built lighthouses all along the Mediterranean to the North Sea (Morhange and Marriner, 2017). However, without systematic dredging, the ports they protected were threatened and later completely destroyed due to silt accumulation. During the Middle Ages, several innovators tried to combat the tenacity of waves, current and wind.

One of these methods was dredging from land. This system consists of a plough that dredges the bottom and is connected to a rotating shaft driven by men on land (Morhange and Marriner, 2017). As the name implies, the Netherlands has part of its territory below sea level. The inhabitants of this area are therefore confronted with various problems and thus have good reason to develop the art of dredging. During the sixteenth century Dutch engineers developed the horse-drawn mud crawler (IADC, 1999). During the seventeenth century, the french Denis Papin invented the centrifugal pump, which consists of transporting a liquid through a pipe by means of a rotating movement. This model was capable of sucking in a large quantity of substances composed of water and solid particles. During the nineteenth century, the drilling of the Suez Canal marked a turning point in the history of dredging. Work began in 1854 using slaves and animals (IADC, 1999). However, it was not until 15 years later that work was carried out using dredgers consisting of a system of buckets driven by chains with the help of steam engines. The completion of this canal shortened the distances between Europe and the Far East by 8,000 kilometers. At the beginning of the twentieth century, it was the turn of the American continent to enter the field of dredging in a tropical country, Panama. After the great success of the Suez Canal, the French were confident that they could repeat the same feat and introduce a canal through the 90 kilometers of Panamanian jungle. In 1904 the Americans bought the French company for $40 million and continued construction. As engineers wanted to find more efficient machines to dredge the thick materials of the Panama Canal, several companies were hired to build six cutter suction dredgers with large pumps and hydraulic lines. Work on the canal was completed in 1914, the largest engineering project of its time.

In Benin, the exploitation of marine sand for the construction of infrastructures has been a common practice for several years (Yaotcha, 2015). In the early 1996's, voices were raised to insist on the need for coastal protection against erosion. Indeed, the rise in sea level has destroyed many homes, hotels, roads and farms to the point of threatening several coastal cities. According to the findings of the consultancy firm in 1981 and the research work of Benin's mining experts, coastal erosion, which is most pronounced east of the Port of Cotonou, would be aggravated by the annual removal of more than 450,000 cubic meters of sand from the coast at Sèmè. Estimates made by these experts showed that in 2007, the retreat of the coast corresponding to a withdrawal of 150,000 cubic meters would be in the order of 60 to 70 meters and more than 200 meters above 450000 cubic meters. Thus, in 2008, aware of the serious danger posed by the phenomenon of coastal erosion on the one hand, and in order to preserve the credit acquired by the country for the construction of coastal protection groins on the other, the Government of Benin prohibited the removal of sand along the coast by Decree No. 2008-615 of 22 October 2008 prohibiting the removal of sand along beaches and in the channel area between the mouth and the old Cotonou bridge. New sites were thus identified by the Beninese Office of Geological and Mining Research) under the project for the Search for Offshore Sand Sites. At the end of the work, deposits were found in water bodies (Lake Nokoué, Porto-Novo lagoon, Ouémé River, Sô River), in the swampy area of Dèkougbé-Hêdomey and around, in the alluvial plains of the Sô and Ouémé Rivers and in the ancient valleys of the southern Allada Plateau. Based on the environmental assessment carried out by the Beninese Environment Agency, the government authorized in 2007 the extraction of sand from offshore areas (lagoons, rivers, shallows) in areas of lesser impact to relieve economic operators and consumers. In addition to mechanical dredging, which has been carried out since then, man has developed another technique for extracting sand. This consists of plunging deep into the water and removing sand using shovels, baskets and seals. This technique is considered traditional and has been observed for some years now in southern Benin, in the Mono and Oueme basins.

Environmental and socio-economic impacts of sand dredging

The available information on the different bio-ecological and socio-economic impacts of sand dredging covers more than 98% of the studies carried out in the marine environment. The remaining 2% mostly concern information on the lagoon environment (Achoh *et al.*, 2018; Djihouessi *et al.*, 2017), even if this information is very superficial and deserves to be deepened. The ecological impacts of sand dredging are multiple. They are interconnected and often result from the first physical modifications of the environment (Duclos, 2012). Many authors around the world have addressed the issue. Indeed, Maya *et al.,* 2012 and Saviour (2012) have pointed out that mining and dredging regulations in developing countries are often established without scientific understanding of the consequences, and projects are carried out without environmental impact assessments. The lack of appropriate scientific methodology for sand extraction is said to be one of the causes (John, 2009; Ashraf *et al.,* 2011; Saviour, 2012; Ghosh, 2012). According to them, this has led to indiscriminate sand extraction, while weak governance and corruption have led to widespread illegal mining. The sand trade is a lucrative business, and there is evidence of illegal trade as in the case of the influential mafias in India. Several other authors (Sreebha and Padmalal, 2011; Velegrakis *et al.,* 2010) have gone in the same direction, emphasizing the lack of adequate information on sand extraction or dredging activity, which limits its regulation in many developing countries. Similarly, access to data is difficult and data are not standardized. Collaboration or coordination between marine scientific research institutions and the marine aggregates industry is limited.

The different bio-ecological and socio-economic impacts of sand dredging activity have been the subject of several studies around the world. Several authors in Africa, Europe, America and Asia have tried to assess and evaluate the different impacts of this activity in the marine environment. Indeed, authors such as Newell *et al.* (1998) and Tillin *et al.* (2011) have shown that the impact generated by this activity depends on many factors, including the method and intensity of extraction, sediment type and mobility, bottom topography, and current intensity. Changes in bathymetry induce changes in wave and current hydrodynamics, which in turn affect the sediment regime at and beyond the extraction area, including erosion and sedimentation conditions of sandy coastlines when dredging is carried out at shallow depths. Other authors (Wijsman and Anderson, 2004) have concurred, also pointing out that the ecological effects of dredging at the water stage depend on a number of factors, including: the method of extraction, the type of sediment (including the fines content at the extraction site), the rate and amount of sediment discharge and local hydrodynamics. A classic example is the destruction of the village of Hallsands in Devon during the 20th century, where dredging was carried out close to the beach, which subsequently led to severe erosion (CIRIA, 1998). In North Africa, and more specifically in Morocco, intensive dredging of the mouth of the Sebou wadi for the maintenance of navigation channels but also for the exploitation of granula, is suspected to be at the origin of the erosion of the Mehdia coastline (DPDPM, 2011). In Japan, sand extraction has led to the deepening and widening of the channel of Lake Poyang and an increase in water flow in the Yangtze River and is believed to have negatively influenced the lowering of the lake water level, which reached a historically low level in 2008 (De Leeuw *et al.,* 2010).

- From a purely biological point of view, it is naturally expected that wildlife biomass will remain reduced due to overfishing, as the fine material will be more easily disturbed by tidal currents, keeping the community in an early successional stage (Kenny and Rees, 1996). Several authors (Desprez, 2000; van der Veer *et al.,* 1985; Desprez, 2000; Van Dalfsen *et al.,* 2001) have shown that an increase in the proportion of fine sand in the deposits following aggregate extraction has been frequently reported and may be associated with a change in the type of wildlife recolonizing the deposits. Similarly, where sediments are more heterogeneous and contain pebbles and gravel, biological interactions are likely to play an important role in community formation (Seiderer and Newell, 1999; Van Dalfsen *et al.,* 2001; Newell *et al.,* 1999; Newell and Seiderer, 2003). According to these authors, coarser sediments can support a wider variety of species, including those that are epilithic. They are also convinced that it is not surprising that marine fauna shows a stronger relationship with sediment composition in sand-dominated deposits. The same authors then examined recovery rates of benthic communities at a wide range of dredging sites and found that recruitment success was mainly controlled by the ability of sediments to settle after dredging was completed. According to (Hitchcock and Drucker, 1996; Gubbay, 2003), during actual dredging, very fine sand dispersed by dredging can be transported up to 11km from the dredged site, fine sand up to 5km, medium sand up to 1km and coarse sand up to 50 m, and high turbidity is caused by a high content of fine sediments and/or organic particles. These high turbidity levels (or high levels of suspended sediment) can be harmful to benthic vegetation and fauna due to shading (blocking of sunlight) and burial by suspended sediments released from dredging (Dankers, 2002). This effect only occurs when the turbidity level is significantly higher than the natural variations in turbidity and sedimentation in the area. Rozenmeijer (1999) also noted that sand extraction activity may inadvertently create an abundance of food in the form of damaged animals such as bivalves or crustaceans and that this may temporarily increase the number of fish and marine mammals present in the area.

They also reported that the removal of large areas of surface sand (by dredging), which are rich in benthic species, has an effect on, for example, plaice, both on the population and on the conditions that allow plaice to spawn successfully. Gubbay (2003) mentions in a study in Australia that wherever fine sediments were dredged, an improvement in the benthic biotope was noted. Seys (2003) concluded that, due to extraction, which probably enriched the waters by releasing organic matter, a large increase in biomass was observed in a study area 100km east of Hull. Some literature suggests that "grinding" of sediments by raft mussels (*Mytilus galloprovincialis*) has been found to improve the ingestion of organic particulate matter, thereby promoting the growth of this species (Navarro *et al.,* 1996). According to research by Dankers (2002) increased concentrations of suspended solids in the water stage could lead to suboptimal gill function in fish due to silt clogging in the gills. Such clogging could lead to infection and even death of the fish.

The same author observed that some fish and mobile invertebrates moved away from the plumes. In a similar vein, these previous authors (Van Dalfsen and Essink 1997; Krause *et al.,* 2010; Desprez *et al.*, 2010; Boyd *et al.,* 2005) in turn point out in their research work that the extraction of sea sand has an impact on the flora and fauna of the seabed and that such dredging in the benthic (seabed) zone destroys organisms, habitats and ecosystems and profoundly affects the composition of biodiversity, generally leading to a net decline in the biomass and abundance of fauna or a change in species composition. Finally, they state that the long-term recovery of this ecosystem can only occur when the original sediment composition is restored. Achoh *et al.* (2018) in Benin in West Africa has shown that river sand dredging affects the hydrology of aquatic environments but at the same time contributes to the improvement of biodiversity productivity. In the course of this research, it was found in the dredged lowland population of *Sarotherodon melanotheron* in Togbin that the eggs produced are larger with a larger size at first sexual maturity than that obtained for the same species in the non-dredged coastal lagoon in Togbin. In the Grand-Nokoué lagoon complex, traditional sand dredging could be beneficial for the fishery because most fishermen believe that sand removal in very specific areas of the complex would improve fish reproduction (Djihouessi *et al.*, 2017). Thus, the author hopes that further in-depth studies will be done to examine the environmental impacts of traditional dredging to help decision-makers manage the balance between mechanical dredging and traditional sand dredging in the Grand-Nokoue.

-From an ecological point of view, Gubbay (2003); Wijsman and Anderson (2004) pointed out that another less positive potential effect of dredging is the decrease in oxygen levels caused by the disturbance of anaerobic sediment layers, and that sand and gravel discharges are exploited globally and represent the largest volume of solid material extracted in the world. According to Van Dolah *et al.* (1998), a deep trench dredged more than 10 m deep 3.6km off Coney Island persisted for more than six years and had a highly modified wildlife assemblage. According to the National Research Council of Canada in 1995, pits that are too deep may have decreased levels of dissolved oxygen in the water that could lead to hypoxic or anoxic conditions. Other authors such as Sreebha and Padmalal (2011) and Saviour (2012) concurred with the latter in reporting that extraction of aggregates from rivers has led to serious damage in river basins including pollution and changes in pH levels. Padmalal *et al.* (2008) also reported that the removal of more than 12 million tons of sand per year from the Lake Vembanad watershed in India resulted in the riverbed being lowered by 7 to 15 centimeters per year. According to Kondolf (1997), the removal of sediment from rivers could result in the excavation of a channel in the valley bottom bed (or incision of the channel) upstream and downstream of the extraction site, causing bed material to thicken and causing lateral instability of the channel. Based on his research, the riverbed could be altered. According to Kondolf (1997), extraction can also increase the frequency and intensity of flooding by reducing the flood control capacity. Myers *et al.* (2000) and John (2009) also pointed out that lowering the water table is the greatest threat to water supply, which exacerbates the frequency and severity of droughts, as tributaries of large rivers dry up when sand extraction reaches certain thresholds.

Much of the erosion in these rivers occurs through the direct removal of sand from beaches, mainly through illegal sand mining. Coastal sand extraction in coastal dune systems such as those in Monterey Bay, California, U.S.A., according to research by Thornton *et al.* (2006) resulted in long-term erosion, in this case 0.5 to 1.5 meters per year. The extraction of sand from marshes, lakes and lagoons causes the degradation of the lagoon banks of the swampy environment and accentuates the degradation of the ecosystems of the soil, flora and fauna. Several authors, notably (Affagnon and Honfoga, 2005; Ahonnon, 2005; Adeble, 2005; Amoussou, 2003, 2010; Bessan, 2008 and Donou, 2007) have reached the same conclusion by emphasizing both the positive and negative impacts of the exploitation of lagoon, river or continental sand in relation to the degradation of natural resources. These results are the result of surveys carried out among the populations and the various stakeholders of the sand industry in southern Benin. Other authors point out that the turbulence generated by the propeller of the dredge on the bottom remobilizes the fine sediments of the sedimentary cover and consequently affects the physico-chemical conditions of the water and habitats. Finally, a survey carried out by Agbo (2013) on "Population mobility in the fluvio-lagoon complex of the lower Ouémé valley in Benin, West Africa shows that the creation of sand quarries all along rivers, lakes and lagoons constitutes an ecological disaster. The same survey revealed that the extraction of sand from the lagoon bottoms creates a break in the ecological corridor: habitat, breeding area, food, morphology and dynamics of the lake, lagoon or even the river. These ecological consequences are accentuated when the extraction is done mechanically in the environment.

- From a socio-economic point of view, a few authors have also addressed the issue. Ghosh (2012) pointed out that the sand trade is a lucrative activity and that there is evidence of illegal trade in the world today. Djihouessi *et al.* (2017) during their research in the Grand-Nokoué lagoon complex in Benin reported that the economic value of traditional (manual) sand dredging is about 2.44 million USD per year and that even though this activity is traditional, many benefits are derived from it, including substantial income for the population. According to Kombieni (2016), the sand mining activity promotes direct and indirect employment creation especially for youth and women. He also pointed out that the activity strengthens the incomes of the various actors, especially the fishermen who have reconverted and allows them to meet the basic needs of their households. At the level of the Nkol'Ossananga quarry, in the central region of Cameroon, a similar and open survey conducted by (Ekengoue *et al.,* 2018) among artisans also revealed that artisanal sand exploitation has become an unavoidable reality, an economic occupation on the same level as agriculture and animal husbandry, and generates foreign currency for the national economy (Sba-Ecosy-CEDRES, 2011). Despite the financial prosperity that this activity offers to the population, the author points out that it is not without consequences on the social life of the actors. Indeed, the populations living near the exploitation sites are affected by several diseases due to sand exploitation. Thus, respiratory tract diseases such as asthma, bronchitis (37% of respondents revealed it), eye diseases such as conjunctivitis and eye blindness (28%), mainly related to sand dust and smoke from heavy machinery (trucks) are frequently recorded by the actors as illnesses and confirmed by the commune's health workers. Ekengoue *et al.* (2018) showed that the population encountered at the Nkol'Ossananga site is threatened by diseases such as dysentery (15%), fibromyalgia (25%), typhoid fever (55%), otalgia (10%), eye pain (15%) and malaria (45%). According to the author, the artisans of Nkol'Ossananga work without personal protective equipment and are often victims of drowning and bacterial infections. On this point, many authors have pointed out that the effects of sand exploitation have many faces (Mutsima *et al.,* 2015): dust, presence of miners in the sites (Kyamwami, 2013; Razack, 2012), lack of drinking water, demographic transfer from rural areas to the mines (Sinonda, 2010; Razack, 2012), insecurity linked to arms trafficking (Geenen *et al.,* 2010), origin of the link between natural resources and conflicts (Collier, 2000; Razack, 2012 and Billon, 2001).

These same authors state that this activity is, in most cases, the source of many occupational accidents, most often fatal, and that on the exploitation sites, there is an absence of basic health and safety rules characterized by precarious working conditions (absence of personal protective equipment, etc.) thus exposing craftsmen to many diseases such as dust-related lung infections, deafness risks related to permanent noise on the site and eye diseases (Goh, 2016). Also Remer *et al.* (1995); Abanda *et al.* (2014) and Mayerling *et al.* (2015) have revealed in their research work that the poor, very unbalanced diet with a very high acid kidney potential to which craftsmen are exposed can lead to acidification of their bodies and that the slight increase in acid kidney potential can lead to extracellular bicarbonate depletion, which in the long term can generate complications for the development and evolution of several pathological conditions. Several other effects produced by acid-base imbalance, such as the progressive and gradual decrease in bone mineralogical content, growth retardation in children, the risk of osteoporosis and sarcopenia in adults and the elderly, hypercalciuria and the formation of kidney stones as a direct consequence of infraclinical methanolic acidosis could be observed (Fressetto *et al.,* 2001; Reddy *et al.,* 2002; Arnett, 2008; Ute *et al.,* 2005; Welch *et al.,* 2013). Following analyses of some water samples from the Sanaga River carried out by (Ekengoue *et al.,* 2018), it appears that the consumption of small quantities of water from this river by underwater divers during their activity exposes them to diseases such as damage to the liver, heart, pancreas, endocrine glands and joints caused by the accumulation of iron in the body. They add that water with a high concentration of nitrogen molecules is unsuitable for human consumption, especially when its concentration exceeds the threshold (50mg/l) set by the World Health Organization (Obeidat *et al.,* 2007).

Consumption of nitrate-rich water exposes to diseases such as cancers of the bladder (Hui-Fen *et al.,* 2007), stomach (Sandor *et al.,* 2001), oesophagus and duodenum (Ward *et al.,* 2008; Khademikia *et al.,* 2013). Finally, Kondolf (1997) reported that tourism can also be affected by beach erosion. According to his analysis, sand is often removed from beaches to build hotels, roads and other tourism-related infrastructure. In some places, continued construction may lead to an unsustainable situation and the destruction of the main natural attraction for visitors: the beaches themselves.

Conclusion

This study is a contribution to the knowledge of the impacts of sand extraction activities in aquatic ecosystems. The results obtained show that several impacts can result from dredging activities. These positive or negative impacts could be physical, ecological, biological and socio-economic. However, most of the existing work on the subject has focused on marine sand dredging. In Africa in general and in Benin in particular, apart from the work of (Djihouessi *et al.,* 2017) on the evaluation of the economic value of traditional sand dredging in the coastal lagoon complex of Grand-Nokoué (CLCGN), of (Achoh *et al.,* 2018) on the comparison of reproduction parameters of *Sarotherodon melanotheron* in dredged shallows and coastal lagoon and (Lalèyè *et al.,* 2019) on the inventory of lagoon and estuarine ecosystems subjected to sand mining activities in southern Benin, no other work has really looked at the impacts of this activity on living aquatic resources in lagoon and estuarine ecosystems in southern Benin.

It is therefore important to examine in greater depth the ecological and biological impacts on the lagoon and estuarine ecosystems subject to this sand dredging activity, particularly on the life of the organisms such as fish to conserving aquatic biodiversity.

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Declaration of interests

No potential conflict of interest was reported by the authors.

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