Diagnostic analysis of the major threats of Lake Tanganyika and proposals for improving its ecological status

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1 Background and Topic Significance

Lake Tanganyika is one of the largest lakes of Africa and second biggest Lake Considering the area after Lake Victoria. Worldwide, it is the longest fresh water lake and holds second position in terms of depth after Lake Baikal and third place in terms of volume after the Caspian Sea and Lake Baikal (Wetzel, 1983 and Kar, 2013). In fact, Lake Tanganyika has a volume of 18 900km^3, covers an area of 34,000 km^2 with a length of 677 km and a width of 72km and is spread on a watershed of 231,000km^2. Its altitude rises to 775m; its average depth is 770m with a maximum of 1433m. Lake Tanganyika is surrounded by four countries sharing unequally 1,838km of its entire perimeter (Hanek and al., 1993): Burundi in the North-East controlling 159 km (9% of the coast), Democratic Republic of Congo (DRC) to the West with 795 km (43% of the coast), Tanzania to the East and South-East with 669 km (36% of the coast) and Zambia to the south with 215 km (12% of the coast). Seven main towns and cities are established on the edge of Lake Tanganyika such as: Baraka, Kalemie and Uvira in DRC, Bujumbura and Rumonge in Burundi, Kigoma in Tanzania and Mpulungu in Zambia. Its waters join the Congo River in DRC via the Lukuga River, then the Atlantic Ocean. However, many decisions in favor of Lake Tanganyika future have been taken at the time of the first International Conference on Conservation and Biodiversity of Lake Tanganyika, held in Burundi-Bujumbura in 1991, where regional and international scientists were present to discuss about the wealth and increasing threats of Lake Tanganyika (Cohen, 1991). Despite all these initiatives, the lake is still subject to frequent fluctuations in the chemistry of its water and to desiccation (Wetzel, 2001) due to sudden changes in weather conditions. It is facing a serious pollution problem from various sources, such as discharge of domestic sewage, population growth, rise of industrialization, use of pesticides and chemical fertilizers in agriculture, sedimentation and erosion resulting from deforestation. So, the surface waters of Lake Tanganyika are highly polluted by different harmful contaminants from human activities in large cities established on its catchment areas. The Figure1 shows the geographical location of Lake Tanganyika.

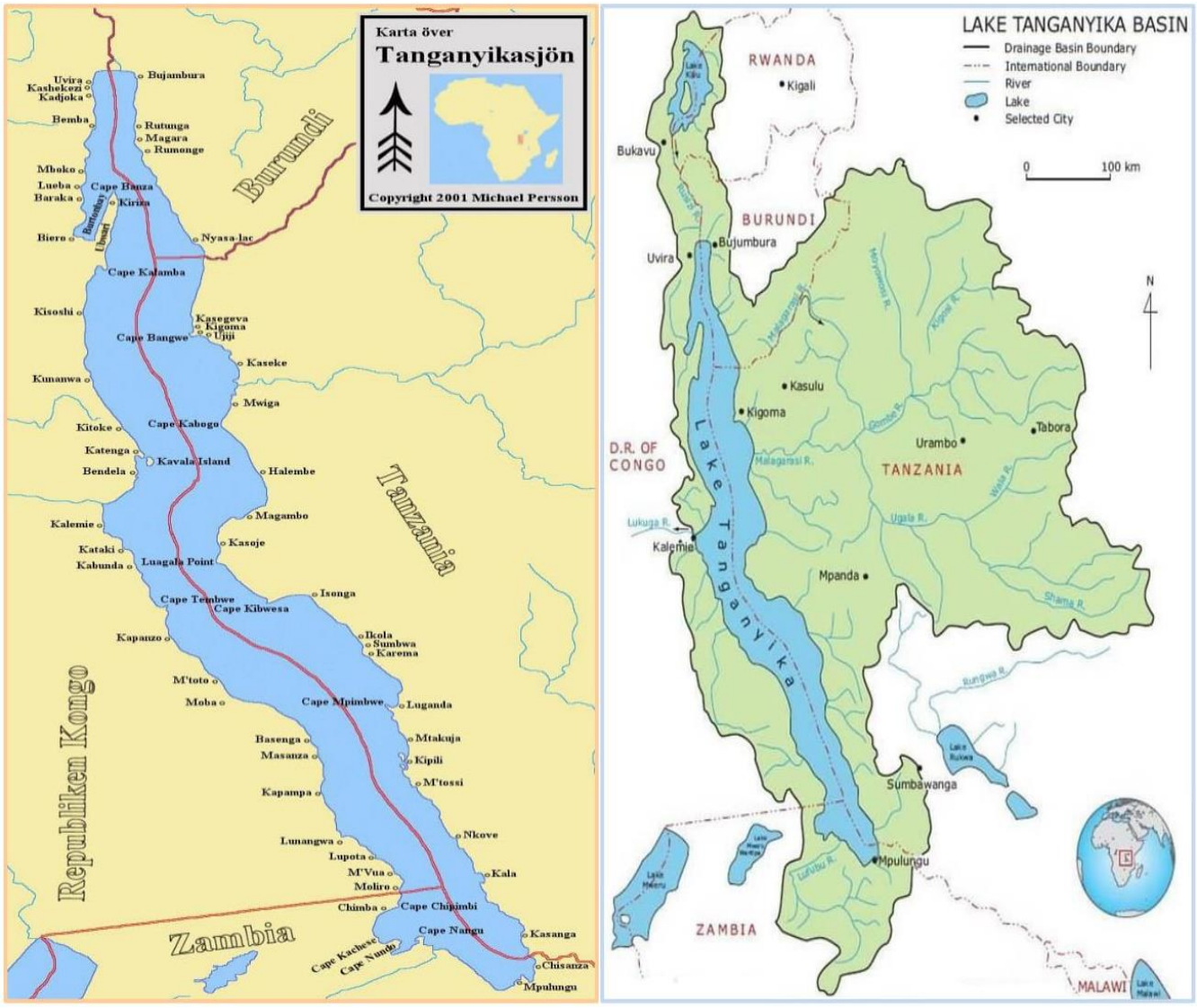

Figure 1: Geographical situation of Lake Tanganyika

2 Main threats of Lake Tanganyika

2.1 Pollution

Pollution is a major threat to Lake Tanganyika's sustainability. Water pollution occurs when wastes are thrown into water bodies without prior treatment (Nzungu, 2017). Industrial and municipal Sewage are not currently treated before entering into the lake and the governments of riparian countries do not have legislation to prevent contamination of the lake. Pollutants include domestic wastes (household dirt, excrement), industrial wastes (stationery, tanneries, slaughterhouses, dairies, oil mills, sugar refineries, etc), heavy metals, fuel and oil from boats, pesticides and chemical fertilizers (Patterson G. & Makin J., 1997). The Large-scale deforestation and unsuitable agricultural practices have amplified the damage caused by erosion leading to sedimentary deposition in the littoral zone (habitat for organisms). Turbidity and changes in substrates can alter habitats, disrupting food chain/web and primary productivity which reducing species diversity (Cohen et al., 1993). The Figure2 shows the different types of pollution in Lake Tanganyika.

Figure 2: Different types of pollution of Lake Tanganyika: Point-Source of domestic pollution (A), Sedimentary pollution owing to rainy erosion (B), Urban wastewater pollution (C) and Industrial pollution (D).

2.2 Overfishing and use of destructive gears

Overfishing and the use of destructive methods alter biological community's structure and food chain, and may have negative socio-economic consequences (Pearce, Petit and Kiyuku, 1995). Studies show that fish stocks have already been drastically reduced through fishing activities (Pearce, Petit and Kiyuku, 1995). Annual fish catches recorded on Lake Tanganyika have been on an upward trend since 1970, currently at around 200 000 tonnes. Recent estimates by country indicate a yield of about 21,000 tons for Burundi in 1992 (94.5kg/ha/year), 55,000 tons for Tanzania in 1994-1995 (60 kg/ha/year), 12,900 tons for Zambia (69kg/ha/year) and 90,000 tons in Democratic Republic of Congo (34 kg/ha/year). These estimates give an average catch ranging from 54to 66 kg/ha/year for the whole Lake (Lindqvist et al., 1999). The observed fishery yields in Burundi (94.5 and 111.5 kg/ha/year, respectively in 1992 and 1995) are close to the potential yield of 100kg/ha estimated by Coulter (1977). The nocturnal Catch per Unit Effort (CPUE) of the commercial units in Burundi decreased from 166 kg in 1994 to 111 kg in 1996, while in Mpulungu it dropped from 877kg in 1994 to 535kg in1996. The decline in catchable stocks of

Luciolates stappersii around Mpulungu city is not compensated. At the northern extremity of the lake, the commercial units have stopped their activities and ***Luciolates stappersii*** represents only around 20% of the commercial catches and the majority of the fish caught are juveniles. The figure 3 shows the Overfishing and use of destructive gears in Lake Tanganyika.

Figure 3: Overfishing (A) and use of destructive gears (B) in Lake Tanganyika.

2.3 Increase of human population

Almost all the Lake Tanganyika's threats are linked to anthropogenic sources. Lack of education on Lake resources conservation, rapid population growth and poverty contribute to environmental damage and habitat destruction in the Lake basin. In riparian countries, the annual population growth rate is from 2.5 to 3.1%. This gradual increase in demographic pressure has forced changes of tropical forest in land use to create small agricultural plots bordering Lake Tanganyika. In addition, infrastructures such as hotels and dwelling houses are being built anarchically in the supra-littoral zone of Lake Tanganyika without prior environmental impact assessment on fragile soils and are subsequently harmful to Lake Tanganyika's environment (Manirakiza, 2017). The installation of these infrastructures results in destruction and degradation of the bordering vegetation which reduce the space needed for feeding and reproduction of the lake's biodiversity. In fact, hippopotamus populations cannot survive without the vegetation used for pasture and temporary conservation of their babies and crocodiles must also have border vegetation to protect buried eggs (Manirakiza, 2017).

2.4 Eutrophication

Eutrophication is an excessive supply of nutrients in an aquatic environment leading to plants proliferation (Algae), oxygen depletion, fish species depletion, general degradation of water quality and the imbalance of the ecosystem.The major nutrients causing eutrophication phenomenon are phosphorus (contained in phosphates) and nitrogen (contained in ammonium ions, nitrates and nitrites) (Nzungu, 2017). Eutrophication is thus manifested by the appearance of large quantities of algae and other invasive plant species acting by excluding other species in

the lake environment. An invasive species representing the most obvious threat to Lake Tanganyika is ***Eichhornia crassipes***, commonly named “water hyacinth” which grows rapidly and spreads along the shore of Lake Tanganyika as well as in the shallow bays and backwaters of the northern extremity of the lake. The consequences include a reduction of fishes catch, aquatic biodiversity and loss of aesthetic and recreational value of the invaded areas (Bikwemu and Nzigidahera, 1997). The figure 4 shows the algal proliferation leading to green colour of Lake Tanganyika water occurring recently on 10th September 2018 while the figure 5 shows *Eichhornia crassipes* (water hyacinth) on the shores of Lake Tanganyika.

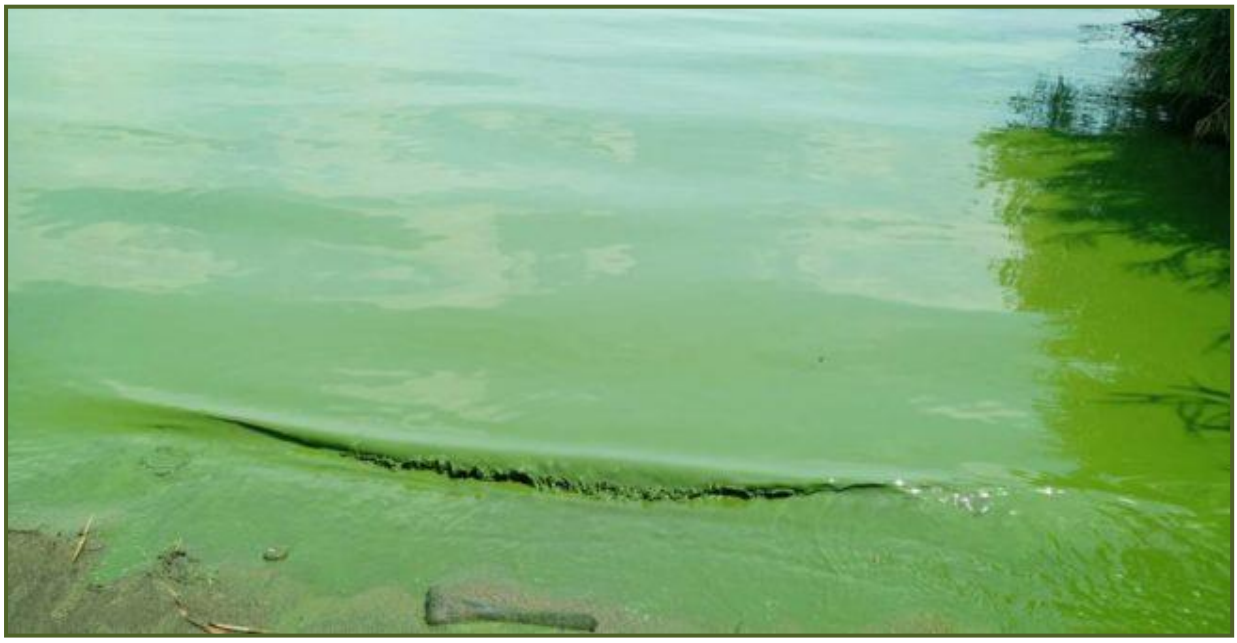

Figure 4: Algal blooms with green colour of Lake Tanganyika water

Figure 5: Proliferation of *Eichhornia crassipes* along LakeTanganyika shores, nearby Bujumbura port

3 Conclusion and Scopes for future

Many chemical substances emitted into the environment from anthropogenic sources pose a threat to the functioning of aquatic ecosystems and to the use of water for various purposes. However, it is imminent that the water quality, biodiversity and natural resources of Lake Tanganyika are increasingly threatened. The necessity of strict measures to prevent and control the release of these substances into the aquatic environment has resulted in the development and implementation of water management policies and strategies for the sustainable management and exploitation of Lake Tanganyika resources. The following strategies are advisable generally to the governments of riparian countries and especially to the peoples living in the catchment of Lake Tanganyika:

- Establishing of a monitoring network for the continuous analysis of the quality of the lake's coastal waters as well as the rivers and streams flowing into the lake.
- Determination of the impassable boundaries for buffer zones around Lake Tanganyika and prohibit the construction of dwelling houses and hotels in the buffer zones of Lake Tanganyika;
- Rehabilitation of existing sewage treatment stations and construction of new stations as human populations is ever-increasing in the northern riparian towns of Lake Tanganyika.
- Sustainable land management by fighting against deforestation in Lake Tanganyika watershed and promoting alternatives solutions to firewood, lumber wood, construction wood and charcoal.
- Pollution mitigation:
  - Reduction of urban and industrial pollution through the collection and treatment of wastewater and solid waste.
  - Minimize the use of pesticides and fertilizers in the Lake Tanganyika catchment by promoting sustainable alternatives strategies.
- Prevention of eutrophication by limiting supply of phosphorus and nitrates from water runoff, erosion and leaching of fertilized agricultural land leading to an increase of nutrients stock in Lake Tanganyika.
- Determination of Heavy metals concentration accumulated in fish tissue and some macro-invertebrates to prevent the health risks to human consumers.

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