

Benefits of plastic removal in African rivers

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Abstract - Plastic in rivers has been an increasing problem over the past decades. The amount of plastic in rivers is growing fast. The report will focus on the benefits of plastic removal in African rivers. The benefits are split up in three categories: environmental, health and economic benefits. Afterwards the relation between these categories are discussed, as they are intertwined a lot. The lesson learned from this report is that the plastic problem is more complex than it seems. There are many steps that need to be taken in order to tackle the problem of plastic in African rivers.



Figure 1: Polluted river in Nairobi, Kenya (Lerner, S. (2020) [18])

I Introduction

Africa is known to be one of the major sources of plastic that enters the ocean [17]. Global plastic pollution is increasing every day of the year. A share of these plastics end up in rivers. Increasing plastic concentrations in rivers have a impact on the economy and both environmental and human health.

This paper will focus on the benefits of plastic removal in African rivers. Currently it is recognised that the amount of plastic needs to be reduced to improve the water quality. A detailed motivation will be given why it is desirable to remove plastic from rivers. Some downsides will be given as well. Environmental, health en economic aspects will be pointed out.

Chapter II will give an overview of the current amounts of plastic in African rivers. The benefits will be split up in three categories. The environmental and health benefits will be discussed in chapter III and IV respectively. Chapter V covers economic benefits of plastic removal. Finally, in chapter VI the relations between the categories will be discussed and a conclusion will be made.

II Numbers

Before discussing benefits of removing plastic from rivers, a few numbers about plastic in African rivers will be given. This is done in order to get a better picture of the current situation. In 2015, Africa was responsible for 7.8% of the total plastic input from rivers into the ocean [17]. This makes Africa the second biggest input of plastics into oceans behind Asia (86%). The Niger and Nile have a top 10 ranking for rivers with the most plastic [25]. One of the reason why the numbers in Africa are so high, is because in many countries more than 80% of all plastic disposal is inadequately managed [14].

III Environmental benefits

One of the consequences of plastic debris in water is animals considering it as food or prey items [26]. These plastic are harmful to animals in multiple ways. When they eat plastic, it could get stuck in their digestion. An example of seabirds, in case plastic gets in their stomachs, they can eat less food. To compensate they need extra body fat, which reduces their fitness [7]. In the worst case the stomach gets completely blocked, which leads to starvation. Plastic can also run up the food chain. Plastics has been found in animals who do not actually get their food directly from rivers or seas. The predators are just not able to digest the plastics that can be found in their preys [9, 11].

Plastics do also have poisonous effects to the environment due to the additives that have been added to improve the micro-structure of the material. These additives can slowly leach into fresh water. For example, some ingredients of PVC and polystyrene can have the

same effect as the hormone oestrogen [21].

Another possibility is that animals get stuck in the plastics. This can lead to the animal drowning, not being able to catch food or avoid predators [16]. It also increases the energy costs of travelling, meaning some animals can not cover long distances like they usually do [10]. This is not only a problem in rivers, but in sea's and oceans as well. Entanglement in plastics generally causes more direct deaths, whereas eating them more often leads to an indirect death [11]. Once an animal has died of entanglement in plastic it will be processed many times faster than the plastic itself. Meaning another animal could get stuck in the same piece of plastic.



Figure 2: Birds entangled in plastic (Ryan, P. G. (2018) [23])

Overall plastics in water reduces biodiversity [1]. Plastic reduces the amount of light that reaches the bottom of a river. Algae and plants need light to produce oxygen. Less oxygen makes it more difficult to survive for a lot of species in the water. Both animals and plants are directly affected by this. A smaller diversity also affects humans, as a major source of food slowly disappears.

Reducing the amount of plastic in rivers will decrease the harmful effects that are stated in the previous paragraphs. This will lead to a healthier environment. One thing to consider is that once plastics will be removed, lots of animals will still have plastic stored in their body. Those harmful (micro-)plastics can't be removed by a regular clean up project as you would need it directly from the animals body.

IV Health benefits

Plastics slowly decay into smaller parts due to external forces and UV light. Once they are smaller than than 5 mm they are called micro-plastics. Those micro-plastics can be found in various food products, like beer, sea salt and tapwater [15]. Considering tapwater

is often purified river water, micro-plastic concentrations can only be larger in rivers. This could be an particular big problem in Africa, since inhabitants get their water more often directly from rivers than in other parts of the world. This goes on top of the micro-plastics people consume through other food.

Although a lot remains unknown about the effect of micro-plastics to the human body, some studies have been published about the subject. Several of those indicate that micro-plastics could have a variety of consequences, e.g. physical toxicity, cellular and DNA damage [27]. These possible consequences are only a few on the list. Although a lot of these consequences have not yet been fully proven, it is clear that micro-plastics have a negative impact on human health.

Plastic causes a faster blockage of rivers than organic material. When plastic starts to accumulate it increases water level and decreases the flow rate [13]. Slow and non flowing rivers are suitable habitats for mosquitoes to lay eggs [19]. The WHO estimated 395 thousand deaths in 2015 by malaria in Africa, while affecting many more people. These numbers have been decreasing over the past decades [28]. Large amount of plastics may contribute to more mosquitoes and therefore an increase in malaria infections, breaking the trend of the past decade. Reducing the amount of plastic will increase the flow speed of rivers, which makes it less suitable for mosquitoes to lay eggs.

A problem related to the rising water level, is an increase in the amount of floods. Fatalities caused by floods were estimated at 15 thousand between 1990 and 2009 [8]. The frequency floods happen only has increased ever since. In 2020 floods in nine East African countries reported more than 430 deaths and affected at least 760 thousand people [2]. In Africa floods are more dangerous because the dikes in other countries like the Netherlands are better in general. The next chapter will focus more on the economic sides of these floods. It is important to realise that floods are not only caused by plastic, two main reasons are seasonality and global warming [24]. As said, higher water levels caused by plastic, do have actually have a contribution to the problem as well.

V Economic benefits

As stated in the previous chapter, accumulated plastic in rivers increases the water level [13]. This also increases the risk of floods. Floods are an already growing problem in Africa, besides causing thousands of deaths, there are economic consequences these floods as well [8]. Currently the total annual costs of floods in Africa are estimated between 5 and 9 billion USD [12]. Floods also force people to move out from their home to a safer place.

Inland fishing is a major source of income and nutrition for a lot of African people. Almost a fifth of the protein intake in Africa is provided by fish [3]. Most of this fish is caught in rivers close to a local market. Chapter IV discussed the consequences of micro-plastics in fish. It was stated earlier plastic reduces the biodiversity, this also reduces the amount of fish. For fishermen it will be more difficult to catch fish in polluted rivers, which lowers their income.

Plastic has a direct economic impact as well. Large pieces of plastic can get entangled in motors of marine vessels, causing damage [20]. Modern and large ships usually have equipment preventing this kind of damage. However, smaller boats of e.g. fishermen do not have this equipment. Cooling systems could be blocked by large pieces of plastic as well. Research done to this subject in Japan estimated the costs at around 0.3% of the total annual fish revenue [20]. This number could be significantly higher in Africa, due to the lack of proper equipment.

Excessive amount of plastics do also have an negative impact on tourism. People generally don't want to see waste during their holidays. For investors in the tourist sector clean environments are also of a larger interest. A decreased revenue out of tourism is concerning for African countries like Tanzania, Namibia and Zimbabwe. Tourism contributes over 8% to their GDP (gross domestic product) [4]. Countries like South-Africa and Morocco are also largely effected since their absolute tourism income are one of the highest in Africa. During the COVID-19 pandemic tourism is one of the sectors that got hit really hard [22]. Plastic removal may contribute to a more attractive sector after the crisis, improving chances of a strong recovery.

A reason why plastic is not yet being removed from rivers on a large scale is mainly because it is not financially beneficial. Existing solutions do cost money to buy and use. New projects for plastic removal do need money too, without having a guarantee on making profit afterwards. The last couple of years there has been an increase request to recycled plastic. Meaning that plastic in rivers still has a market value. Currently unsorted plastic has a market value of 200 euros a ton according to the Delft Global Initiative. When all kinds of plastic are separated from each other the market value increases to 800 euro a ton [6]. If plastic removal becomes profitable, by either lower costs or higher revenue, it might become a large business.

Plastic waste in rivers is also a source of income for some Africans. When there a large amount of plastic stacked up in water, people are scavenging it hoping to find food or valuable items. These places are important for the people who get their resources from here.

When these places disappear people need to find another source of food and income. There are also some small projects that pay people to collect waste. Project butterfly is one of these projects. Their goal is do educate about the waste and facilitate clean up activities [5].

VI Discussion

So far the benefits of plastic removal have been discussed in three several categories. However, these categories are more related than it seems. Economic aspects directly influence health benefits and vice versa. Obviously not all relations between the subjects will be touched, because there are just too many. This chapter will discuss some of these relations. Afterwards the lesson learnt from this report will be concluded.

First of all, plastic has a complex role in food supply. In chapter V it was found that fish is a big part of the protein of African people. Fish is often caught with nets made from plastic. The fishing nets often get discarded into the rivers when are not suitable for use anymore. Nets are more dangerous than most other objects because they are designed to catch and kill fish. Reducing plastic nets in the water does affect the fishers as well. When fishers have to switch to other fishing methods it is obvious it will bring extra costs. Often people don't have this money, so it is difficult to bring a direct change in the way fishermen work. What can be changed without a lot of costs is the way fishermen discard their nets. Bringing them to a place where they can processed in way that is better for the environment than throwing them into the river will already help. This is an example of how economic aspect do effect the environment.

A second relation between the categories is about biodiversity and tourism. Tourist often go to Africa to see something of more the culture and nature. A cleaner environment without plastics is more attractive for tourist to visit. This will lead to a higher revenue in the tourist sector of some areas. At the same time tourists bring the risk of creating more plastic waste at their destination. Which means a certain balance exists between the quality of the environment and income from the tourist sector.

As already indicated, floods affect all three aspects. It is a natural phenomenon that can appear more often because of plastic. Currently extreme weather is something that happens more often all across the world. Reducing the impact of plastic through floods will have a positive influence on the health and financial situation of people. Hundreds, if not thousands of deaths could be prevented in the coming years by reducing the plastic amount.

The final relation that will be touched, is probably the most important. Throughout this report many benefits of plastic removal have been stated. This raises the question why so little people and instances are doing something. One of the answers to this is money. It is financially not profitable to remove plastic from rivers. Investments in plastic removal projects are mainly done to do something good for the environment. Another reason could be realisation, not enough people realize what impact of plastic is and what can be done about it.

The one thing I have learned from this report is the complexity of the problem. There is not only one reason why plastic should be removed from rivers. There are so many aspects that need to be considered while tackling this problem. So many benefits of plastic re-

moval have been stated, which makes me really think why there so little attention for this subject. I do really think investments need to be done in the near future to improve water quality. Maybe once things get going, it will become cheaper to remove plastic. This might even take the interest of commercial parties who only want to make profit. In the end we all need to care for our planet.

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References

- [1] Azevedo-Santos, V. M., Brito, M. F. G., Manoel, P. S., Perroca, J. F., Rodrigues-Filho, J. L., Paschoal, L. R. P., Gonçalves, G. R. L., Wolf, M. R., Blettler, M. C. M., Andrade, M. C., Nobile, A. B., Lima, F. P., Ruocco, A. M. C., Silva, C. V., Perbiche-Neves, G., Portinho, J. L., Giarrizzo, T., Arcifa, M. S., and Pelicice, F. M. (2021). Plastic pollution: A focus on freshwater biodiversity. *Ambio*.
- [2] Celestial, J. (2020). Exceptional rainfall and record floods hit African Sahel.
- [3] Chan, C. Y., Tran, N., Pethiyagoda, S., Crissman, C. C., Sulser, T. B., and Phillips, M. J. (2019). Prospects and challenges of fish for food security in Africa.
- [4] Christie, R., Fernandes, E., Messerli, H., and Twining-Ward, L. (2013). Tourism in Africa. Technical report, The World Bank.
- [5] Daugherty, S. (2021). Stemming the tide of waste in a polluted river. *National Geographic*.
- [6] Delft Global Initiative (2021). Plastic-free rivers.
- [7] Derraik, J. G. (2002). The pollution of the marine environment by plastic debris: A review.
- [8] Di Baldassarre, G., Montanari, A., Lins, H., Koutsoyiannis, D., Brandimarte, L., and Blöschl, G. (2010). Flood fatalities in Africa: From diagnosis to mitigation. *Geophysical Research Letters*, 37(22).
- [9] Emmerik, T. and Schwarz, A. (2020). Plastic debris in rivers. *WIREs Water*, 7(1).
- [10] Feldkamp, S., Costa, D., and Dekrey, G. (1989). Energetic and behavioral effects of net entanglement on juvenile northern fur seals, *Callorhinus ursinus*. *Fishery Bulletin*, 87(1):85–94.
- [11] Gall, S. C. and Thompson, R. C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin*, 92(1-2):170–179.
- [12] Hinkel, J., Brown, S., Exner, L., Nicholls, R. J., Vafeidis, A. T., and Kebede, A. S. (2012). Sea-level rise impacts on Africa and the effects of mitigation and adaptation: an application of DIVA. *Regional Environmental Change*, 12(1).
- [13] Honingh, D., van Emmerik, T., Uijttewaal, W., Kardhana, H., Hoes, O., and van de Giesen, N. (2020). Urban River Water Level Increase Through Plastic Waste Accumulation at a Rack Structure. *Frontiers in Earth Science*, 8.
- [14] Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., and Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223).
- [15] Kosuth, M., Mason, S. A., and Wattenberg, E. V. (2018). Anthropogenic contamination of tap water, beer, and sea salt. *PLOS ONE*, 13(4).

- [16] Laist, D. W. (1987). Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Marine Pollution Bulletin*, 18(6 SUPPL. B):319–326.
- [17] Lebreton, L. C. M., van der Zwet, J., Damsteeg, J.-W., Slat, B., Andrady, A., and Reisser, J. (2017). River plastic emissions to the world’s oceans. *Nature Communications*, 8(1).
- [18] Lerner, S. (2020). Africa’s exploding plastic nightmare. *The Intercept*.
- [19] Lines, J. (2002). How not to grow mosquitoes in African towns. *Waterlines*, 20(4).
- [20] McIlgorm, A., Campbell, H. F., and Rule, M. J. (2011). The economic cost and control of marine debris damage in the Asia-Pacific region. *Ocean and Coastal Management*, 54(9):643–651.
- [21] Rochman, C. M., Browne, M. A., Halpern, B. S., Hentschel, B. T., Hoh, E., Karapanagioti, H. K., Rios-Mendoza, L. M., Takada, H., Teh, S., and Thompson, R. C. (2013). Classify plastic waste as hazardous. *Nature*, 494(7436).
- [22] Rogerson, C. M. and Rogerson, J. M. (2020). COVID-19 and Tourism Spaces of Vulnerability in South Africa. *African Journal of Hospitality, Tourism and Leisure*, 9(4):382–401.
- [23] Ryan, P. G. (2018). Entanglement of birds in plastics and other synthetic materials. *Marine Pollution Bulletin*, 135:159–164.
- [24] Schiermeier, Q. (2011). Increased flood risk linked to global warming. *Nature*, 470(7334).
- [25] Schmidt, C., Krauth, T., and Wagner, S. (2017). Export of Plastic Debris by Rivers into the Sea. *Environmental Science & Technology*, 51(21).
- [26] Shaw, D. G. and Day, R. H. (1994). Colour- and form-dependent loss of plastic micro-debris from the North Pacific Ocean. *Marine Pollution Bulletin*, 28(1):39–43.
- [27] Vethaak, A. D. and Legler, J. (2021). Microplastics and human health. *Science*, 371(6530).
- [28] WHO (2015). World Malaria Report. Technical report, World Health Organisation.