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FACTORS CONTRIBUTING TO POLLUTION IN THE MARA RIVER WITHIN KENYA

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Abstract: **The Mara River Basin is seen to support a wide range of human and ecosystem water needs. However, increased population growth, agricultural expansion, headwater deforestation, water abstractions, and untreated wastewater releases pollute and threaten the supply of sufficient and clean water to all stakeholders and sectors within the Mara River Basin. Increasing water demands in the upper basin in combination with contamination sources also seriously threaten the environmental flows needed to sustain wildlife in the Basin. This article will discuss the factors contributing to pollution in the Mara River within Kenya, identify the source of these pollutants and provide solutions and strategies that will stop pollution in the River. Regular and methodical monitoring and reporting of water quality across the basin and enforcement of regulations and laws is vital to achieving an integrated water resources management program that meets the needs of the various water use sectors, eradicates pollution and supports ecosystem needs in the Mara Basin.**

Keywords: **Pollution, river pollution, Mara River, Mara River pollution, Kenya.**

1. INTRODUCTION

Rivers provide many social and ecological functions to those living in the environment around them and are thus vulnerable to pollution due to exploitation and increased human activity. This can occur either directly or indirectly and this then negatively affects the users of the river's water (Matano et al., 2015). The management of the Mara River falls between the two countries that share it; Kenya (under the Kenyan Environmental Law) and Tanzania (under the Tanzanian Environmental Law) which encumbers the rational management of the shared river and its resources. Two of the world-famous protected areas, the Maasai Mara National Reserve in Kenya and the Serengeti National Park in Tanzania, are supported by the Mara River Basin. Studies have shown that approximately 90% of all the fresh water resources in Africa are shared by two or more countries and the Mara River is no exception (Muigua, Wamukoya, & Kariuki, 2015).

The Mara River basin (MRB) lays in south-western Kenya and north western Tanzania. The basin covers 13,750 km^2 of which 65% is in Kenya and 35% in Tanzania. The River originates from the Enapuyiapui swamp in the Mau Escarpment (2932 m asl) flowing through the plains of the Maasai Mara National Reserve (MMNR) in Kenya, Serengeti National Park in Tanzania and Mara wetland, and eventually into Lake Victoria (GLOWS-FIU, 2007). The trans-boundary landscape is a mosaic of unique ecosystems which includes large parts of the Mau Forests Complex (the largest remaining indigenous montane forest in East Africa and Kenya's largest 'water tower), the Mara River itself, its main tributaries (Nyangores and Amala) and the world-famous Mara-Serengeti ecosystem (home to relict populations of World Wildlife Fund (WWF) flagship species and other important components of biodiversity) (GLOWS-FIU, 2007). An image of the hydrology of the Mara River Basin is shown below:

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Figure 0: Mara River Basin Hydrology

The Mara River is the lifeline for the landscape's rich biodiversity and sustains the world's greatest wildlife migration phenomenon considered the 8th wonder of the world. The River also supports agriculture, livestock production and tourism and thus is closely tied to livelihoods of tens of thousands of people both in Kenya and Tanzania. WWF's conservation target in the entire Mara River system includes the headwater forest (the Mau Forest Complex), the river itself with its tributaries and wetlands, and the middle catchment which is mainly made up of wildlife rich rangelands (GLOWS-FIU, 2007).

The 395km long river faces numerous threats (affecting both water quality and the flow regime) most of which emanate from human related activities. These include: unregulated water abstractions leading to over-abstraction especially during the dry season and droughts; forest degradation in the upper catchment compromising the flow regime of the river; unsustainable agricultural activities that result in high soil erosion levels and subsequent heavy sediment loads in the river; poorly planned settlements along the Mara River without proper sewage treatment systems; proliferation of tourist facilities and artisanal gold mines along the Mara River (most of which do not have effective waste-water management systems); encroachment and degradation of wetlands including critical spring sources and the Mara Wetland; and persistent and frequent droughts linked to climate variability and climate change (GLOWS-FIU, 2007).

The World Wildlife Fund-Kenya (WWF-KE) has a goal that by 2030, the ecological functioning of the Mara river ecosystem and the goods and services it provides to businesses and communities will have been improved thus ensuring that levels of water contaminants are maintained within acceptable standards and that minimum flows meet e-flow requirements (GLOWS-FIU, 2007). The Mara Basin is roughly divided into four land use units. These are: (1) the forested upper catchment of the Mau Escarpment that forms the headwaters of the river and mainly supports (other than forests) both small scale agriculture (less than 10 acres) and medium-size farms (often tea farms up to 40 acres), (2) the Kenyan Rangelands which are comprised mainly of open savannah grasslands that are mostly governed by group ranches and conservancies and used as pasture for livestock and for both small and large-scale agriculture (more than 40 acres), (3) the savannah plains made up of mainly the Maasai Mara Game Reserve in Kenya and the northern part of the Serengeti National Park in Tanzania, and (4) downstream Tanzania where the river runs through another 70km of small-scale subsistence agriculture, small scale mining and one of the largest gold mines in Tanzania (Acacia Gold Mine) before the river meanders into the Mara Wetland that filters all the inflows before discharging into Lake Victoria (GLOWS-FIU, 2007).

Unregulated water abstractions leading to over-abstraction is one of the major threats to the Mara River especially during the dry season and droughts when the river is struggling to meet environmental flows. WWF-KE is championing for community led initiatives to reverse the vice. Forest degradation in the upper catchment compromises the flow regime of the Mara River. WWF-KE is working with forest communities to protect this resource while at the same time, championing for benefit sharing. Unsustainable agricultural activities in both small-scale agricultural activities in the upper and mid-catchment, and pastoralism in the lower catchment has resulted in high soil erosion levels and subsequent heavy sediment loads in the Mara River. Through PES, WWF-KE is working with farmers in the upper catchment to embrace sustainable land management to reduce siltation in the river (GLOWS-FIU, 2007).

Through adoption of constructed wetland, we can contribute widely towards protection of the Mara River. WWF-KE is working with hotels and lodges in the Mara to embrace sustainable effluent management through Constructed Westland. As per the law, hotels and lodges are supposed to meet effluent discharge standards. WWF and partners have over the past few years (most notably during the HSBC Water Programme) introduced appropriate technologies (largely constructed wetlands) for the treatment of effluent from hotels and lodges in the Mara ecosystem (GLOWS-FIU, 2007).

Proliferation of tourist facilities and artisanal gold mines along the Mara River, most of which do not have effective wastewater management systems, threaten the Mara River. Tourist facilities in the Mara ecosystem continue to embrace appropriate technologies for waste-water management aimed at ensuring effluent discharge standards are adhered to. Similarly, small scale gold miners are also embracing the use of alternative and safe mining methods aimed at addressing mercury pollution. The Mara River drying up would threaten the lives of communities, wildlife, livestock, aquatic life and interfere with economic activities on which the basin's inhabitants rely on. Through PES, WWF-KE is engaging with farmers in the upper catchment to embrace sustainable land management. The program resulted in reduced soil erosion and increased soil fertility that translated to increase in farm productivity and improved food security (GLOWS-FIU, 2007).

Problem Statement

The Mara River and its resources are vital for the development of the infrastructure, wildlife sustenance, agriculture, fishing and domestic activities of those within its environs in the two countries. There is thus need for international cooperation of the two countries and mutual strategic planning to properly manage the Mara River Basin and its resources to achieve sustainable development. The two countries have, over the years, continued to exploit the resource separately without the successful implementation of international regulations. This has brought about increased levels of pollution, erosion and sedimentation of the river which relies on a pristine environment for the survival of various species and biodiversity that rely on the river. There is rapid population growth, infrastructural growth and unplanned development around the river and this is detrimental to the environment (Muigua, Wamukoya, & Kariuki, 2015).

The main purpose of the study was to investigate the factors contributing to pollution in the Mara River within Kenya and create awareness and influence interventions that will lead to a healthy perennial river with sufficient water of good quality to support livelihoods, biodiversity and unique ecological processes in the Mara Region.

Significance of the Study

Water is life, without it we are nothing. However, the water that we drink, use to wash and grow crops with is under threat. World leaders have signed up to ground breaking commitments for sustainability and we all need to play our part to protect our natural resources and ensure access to safe water for all. 650 million people do not have access to an improved source of drinking water, while 2.3 billion people live without access to basic sanitation. As populations grow and our world becomes more industrialised, water quality is declining, threatening human health and freshwater species. Since 1970, populations of freshwater species around the world have declined by 76%. Together, we are tackling the water challenge and supporting livelihoods through water provision, protection, education and research. We believe that water is vital for us to realise our ambitions for healthy communities, healthy environments and to prosper and succeed. Without water, we are nothing. With water, we can take the first step out of poverty, have safe water to drink, wash and grow crops. It is our ambition to help provide a safe and sustainable water supply for everyone. The Mara HSBC Water Programme believes that water is vital to building healthy communities, healthy environments and developing national economies. The water challenges are daunting, but not impossible to overcome.

This research article fills an existing knowledge gap concerning the factors contributing to pollution in the Mara River and thus provides a point of reference for academics. It also creates awareness and influence interventions that will address the issue of pollution in the Mara River. In addition, it provides environmental management bodies within Kenya and Tanzania with the information concerning the causes and sources of pollution in the Mara River and thus enable them to take action in eradicating pollution. Finally, it informs policy makers and government agencies of the two countries with solutions and strategies that, if properly implemented, will ensure pollution is eradicated.

2. LITERATURE REVIEW

Water quality is a term that is used to express the fitness of water to sustain various uses or processes. Any specific use will have certain requirements for the physical, chemical or biological characteristics of water; for instance, limits on the concentrations of toxic substances for drinking water use, or restrictions on pH and temperature ranges for water supporting invertebrate communities. Therefore, water quality can be defined by a range of variables which limit water use. Although many uses have some shared requirements for certain variables, each use will have its own demands and influences on water quality (Bartram & Ballance, 1996).

Water quality is affected by a wide range of both natural and human influences. The most important of the natural influences are geological, hydrological and climatic influences since these affect the quantity and the quality of water available. Their influence is generally highest when available water quantities are low and maximum use must be made of the limited resource; for example, high salinity is a frequent problem in coastal and arid areas. Seawater or saline groundwater can be desalinated if the financial and technical resources are available; but in many circumstances this is not practicable. Therefore, even though water may be available in adequate quantities, its unsuitable quality limits the uses that can be made of it. Although the natural ecosystem is in harmony with natural water quality, any substantial changes to water quality will usually be disruptive to the ecosystem (Bartram & Ballance, 1996).

The consequences of human activities on water quality are both widespread and varied in the degree to which they disrupt the ecosystem and/or restrict water use. Pollution of water by human faeces, for instance, is attributable to only one source; but the reasons for this type of pollution, its impacts on water quality and the necessary corrective or preventive measures are varied. Faecal pollution may occur because there are no facilities in the community for waste disposal, because collection and treatment facilities are insufficient or improperly operated, or because on-site sanitation facilities like latrines drain directly into aquifers (Bartram & Ballance, 1996).

Water quality may be described in terms of the concentration and state (dissolved or particulate) of some or all of the organic and inorganic material present in the water together with certain physical characteristics of the water. It is determined by in situ measurements (measurements done in the natural or original position/place) and by examination of water samples on site or in the laboratory. Therefore, the main elements of water quality monitoring are on-site measurements, the collection and analysis of water samples, the study and evaluation of the analytical results, and the reporting of the findings. The results of analyses performed on a single water sample are only valid for the time and location at which that sample was taken. Therefore, one purpose of a monitoring programme is to gather sufficient data (by means of regular or intensive sampling and analysis) to assess spatial and/or temporal variations in water quality (Bartram & Ballance, 1996).

Water Pollution

Water pollution has become a universal problem nowadays. Constant evaluation of water resource policy is needed to counter this problem. Deaths and diseases are caused worldwide because of water pollution and approximately 14,000 people die every day because of water pollution. Both developed and developing countries are facing water pollution problems. Water quality is affected by many factors such as precipitation, climate, soil type, vegetation, geology, flow conditions, ground water and human related activities. The biggest threat to water quality is posed by point sources of industries and municipalities. Activities like urban development, mining, and agriculture also affect water quality. Non-point source pollution also includes sediments, nutrients, and toxic contaminants (Chaudhry & Malik, 2017).

Pollutants are substances which, when introduced into the environment, cause undesirable effects or spoil the environmental resources. Long or short-term damage may be caused by pollutants. Bio-degradable pollutants cause short term damage. Some pollutants like DDT again produce pollutants upon degradation like DDD and DDE. Pollutants may be of different kinds and may have different properties like stock pollutants which include non-biodegradable plastics,

synthetic chemicals and heavy metals which have no or very little absorptive capacity. These pollutants accumulate in the environment with the passage of time. Their damage to the environment increases as their quantity increases. To the future generations, stock pollutants are a burden. Similarly, fund pollutants have some absorptive property in the environment. They only cause problems when their quantity increases beyond the environment absorbance capacity, e.g., carbon dioxide only causes problems when its amount increases. These fund pollutants can only be diluted to reduce their toxicity or recycled into non-harmful substances (Chaudhry & Malik, 2017).

Water pollution can occur as a result of point source pollution, non-point source pollution, and ground water pollution. Some of the pollutants include urban storm water runoff, agricultural pollutants, atmospheric pollutants, pathogens, pesticides and herbicides, chemical pollutants, sediment pollution, and saltwater intrusion (Chaudhry & Malik, 2017).

Factors Contributing to Water Pollution

The world experiences various water related problems including water scarcity and waterborne diseases brought about by many factors. Waruguru et al. (2011) identified water pollution as one of the major problems facing many countries of the world. Water pollution is caused by a variety of anthropogenic and natural factors. For instance, it may result from the discharge of various substances directly into the water bodies, or indirectly through the catchment areas. Muiruri et al. (2013) identified weathering of soils and rocks and a variety of anthropogenic activities as the two independent factors that result into the presence of heavy metals in water thus creating a communal health risk in rivers that are otherwise useful for domestic purposes.

According to Deepali (2010), heavy metals are vital for proper functioning of biological systems but their deficiency or excess could lead to a number of problems. These problems are worsened by poor waste management from unplanned settlements and higher population growth rates without a corresponding improvement in the appropriate necessary infrastructure.

Water pollution has been an unending problem in the world since the beginning of civilization. Howarth et al. (2002) reported that about 60% of coastal rivers and bays in the U.S. have been moderately to severely degraded by nutrient pollution and attributed the cause of the pollution to increased human activity. In a case study of the Ganges River in India, Sharma (1997) reported that human activities mostly contributed to the pollution of the four major river basins of which the Ganges sustained the largest pollution. The study found that 75% of the pollution load was from municipal sewage and that most of the surrounding cities lacked sewage treatment facilities.

Kenya has also not been an exception concerning water pollution particularly in rivers. Water resources in Kenya are increasingly becoming polluted from both point sources and non-point sources due to urbanization, agriculture, and industries which contribute to organic, inorganic and aesthetic pollution of water (Kiithia, 2012). As with other developing countries, the process of industrialization has worsened the pollution of water bodies. Kiithia (2012) saw that the problem of water pollution and water quality degradation in the developing countries is increasingly becoming a threat to the natural water resources and that this phenomenon is attributed to the increasing goals of these countries to attain industrialization status and diversification of the national development goals. Kenya is no exception to this.

Pollution of some rivers in Kenya has been documented by various studies and reports. Musyoki et al. (2013) in an assessment of the quality of Nairobi River and Athi River found out that the waters were highly contaminated with pathogenic bacteria. Musyoki (2012) stated that pollution of Nairobi River and Athi River was also caused by effluents from the Dandora Sewage Treatment Plant (DSTP). Waruguru et al. (2011) observed that Nairobi City has experienced rapid industrialization and population growth in the last 100 years but the population growth and increased industrialization have not been matched by development of infrastructure to effectively deal with waste disposal. Consequently, the unplanned disposal of garbage, human and industrial waste has resulted in increased pollution of water bodies (Waruguru et al., 2011).

Initial research reports on the water pollution problem in Kenya dates back to the 1950's. The problem of water pollution was first exposed by MOWD (1976 a & b) in a case study of three rivers; Nzoia, Nyando and Kerio Rivers. These reports contain the chemical characteristics of the river water shortly before and after establishment of factories along their courses. Nzoia River which discharges into Lake Victoria carries the effluents discharged from Pan Africa Paper Mill in Webuye and from Mumias Sugar Factory; River Nyando which also discharges into Lake Victoria carries the effluents discharged from Chemilil and Muhoroni sugar factories. Kerio River which drains the Kerio Valley with sporadic flow

into Lake Turkana is periodically polluted by effluents from fluorspar factory. All these three reports are a clear indication of the effects of industrial growth on the quality of water as their effluents are a major contributing factor to water pollution (Kiithia, 2012).

3. METHODOLOGY

A case study research design was adopted for this study. This study was conducted in the Mara River Basin within Kenya. The Mara River Basin in Kenya covers Nakuru, Bomet, and Narok. The basin covers 13,750 km^2 of which 65% is in Kenya and 35% in Tanzania. The population of the Mara River Basin is approximately 1.1 million people, with a population growth rate of 2.7%. Approximately 775,000 people live in the Kenyan sub-basin, and the remaining 325,000 live in the Tanzanian sub-basin. The target population for this study are the occupants and workers within the Mara River Basin in the Kenyan side.

Primary and secondary data have been used in this study. The study has employed purposive and convenience sampling methods to obtain the primary data. Furthermore, the researchers have employed key informant interviews and observation as one of the data collection methods. The primary data in this study is the data that has been collected with the help of the interviews and observation. Secondary data has been taken from documented records and reports. Validity of the research instruments has been ensured by performing a pilot test and getting feedback before going to the field for actual data collection.

The first stage of the analysis in this study is descriptive analysis which has helped in understanding the basic distributions from the summarized data. Inferences were then made from the analysis results. The software packages that were used in aiding in coding, analysis and presentation are Microsoft Excel and the Statistical Package for the Social Sciences (SPSS).

For ethical considerations, ethical issues related to the study were addressed by maintaining neutrality and ensuring utmost confidentiality of the information volunteered by the respondents. The interview with the respondents was not recorded without their consent and they have been informed of the purpose of the research. Importantly, the researchers maintained respect and were sensitive during interviews. Finally, the researchers did not undertake any activity without the approval of the concerned officials in the various agencies or institutions.

4. RESULTS AND DISCUSSION

This section provides the results through an analysis of the various environmental management practices, policies and regulations in place in Kenya and the actual happenings in the Mara River. In Kenya, the Ministry of Water and Irrigation (MWI), formerly known as the Ministry of Water Resources and Development (MWR&D) has a fundamental goal and purpose of conserving, managing and protecting water resources for socio-economic development. The Water Act No. 8 of 2002 provides an enabling institutional and legal framework for the implementation and realization of the objectives stated in the National Policy on Water Resources Management and Development. The Act provides for the Water Resources Management Authority (WRMA) which maintains the responsibility of ensuring the good management of the country's water resources. The WRMA has drafted a Country Strategy Paper on Integrated Water Resources Management (GLOWS-FIU, 2007).

Integrated water resources management is a process that promotes the coordinated development and management of water, land, and other resources to maximize the economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. It is a participatory planning and implementation process, based on reliable science that brings stakeholders together to determine how to meet society's long-term needs for water resources while maintaining essential ecological services and economic benefits (WREM International Inc., 2008).

In Kenya, the closest framework built on the concept of integrated water resources management is found in the framework establishing the regional development authorities. In regard to the Mara Basin, the relevant regional development authority is the Lake Basin Development Authority (LBDA), established by the Lake Basin Development Authority Act. The functions of the LBDA are primarily to plan for and coordinate the development of the area and to initiate project activities identified through such planning. The LBDA has the main advantage that it is uniquely structured around a catchment as the basic planning unit (WREM International Inc., 2008).

However, these regional development authorities have not managed to establish themselves as vital players in the water resources management sub-sector. Planning for water resources management and coordination of water resources management activities have continued to be carried out on a sectorial basis, by Water Ministries within the framework of administrative districts, completely outside the catchment-based legal and institutional framework provided for in the regional development authority framework. This reality demonstrates the difficulties that countries have experienced in implementing the concept of integrated water resources management in their water resources legal and institutional frameworks.

In Kenya, the Water Resources Management Authority (WRMA) has already established its formal institutions, namely the Board, national and regional offices and Catchment Area Advisory Committees (CAACs) and is presently in the process of operationalizing them in the Mara River Basin. The Mara River Basin in Kenya is managed by a WRMA sub-regional office in Kericho. A coordination office at Bomet District specifically handles all Mara water resources management issues. A Mara River Water Resources Users Association (MRWRUA) in the Kenyan part of the basin has also been formed (WREM International Inc., 2008).

The responsibility for water supply and sewerage service delivery is given to Water Services Boards who in turn contract Water Service Providers (WSP) such as water companies, NGOs, institutions, and community owned schemes, to provide the day-to-day water supply services within their areas of jurisdiction. For example, in Bomet District, Lake Victoria Water Service Board (LVWSB) has contracted Chemosit Water Company to supply the town with water from a Mara tributary. Lake Victoria Water Service Board (LVWSB) is responsible for delivery of water services in the Mara Basin. LVWSB is regulated by the Water Services Regulatory Board (WSRB). The Water Service Providers are required to submit specific data about their facilities and operations, such as consumer and water use data, among other statistics, to LVWSB every year (WREM International Inc., 2008).

5. CONCLUSION

This aim of this research article was to discuss the factors contributing to pollution in the Mara River within Kenya. This section concludes on the importance of the Mara River and the variances in managing the Mara River.

The Mara River Basin supports a wide range of human and ecosystem water needs. However, increased population growth, agricultural expansion, headwater deforestation, water abstractions, and untreated wastewater releases threaten the supply of sufficient and clean water to all stakeholders and sectors within the Mara River Basin, especially in the dry season. Increasing water demands in the upper basin in combination with contamination sources also seriously threaten the environmental flows needed to sustain wildlife in the Maasai Mara National Reserve, Serengeti National Park, and Mara Wetlands (WREM International Inc., 2008).

Regular and methodical monitoring and reporting of water quality across the basin by local water offices/agencies and major water users is vital to achieving an integrated program of water resources management that meets the needs of the various water use sectors while simultaneously supporting ecosystem needs in the Mara Basin.

The stakeholders of the Mara River Basin in Kenya and Tanzania need to come up with a strategy aimed at providing a mechanism through which they can jointly identify and prioritize specific development projects targeted at addressing water resources related issues and challenges in the basin to stimulate economic development and improve the livelihoods of those living within the Mara River Basin.

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