Contemporary and emerging pollutants in Nairobi river, Kenya

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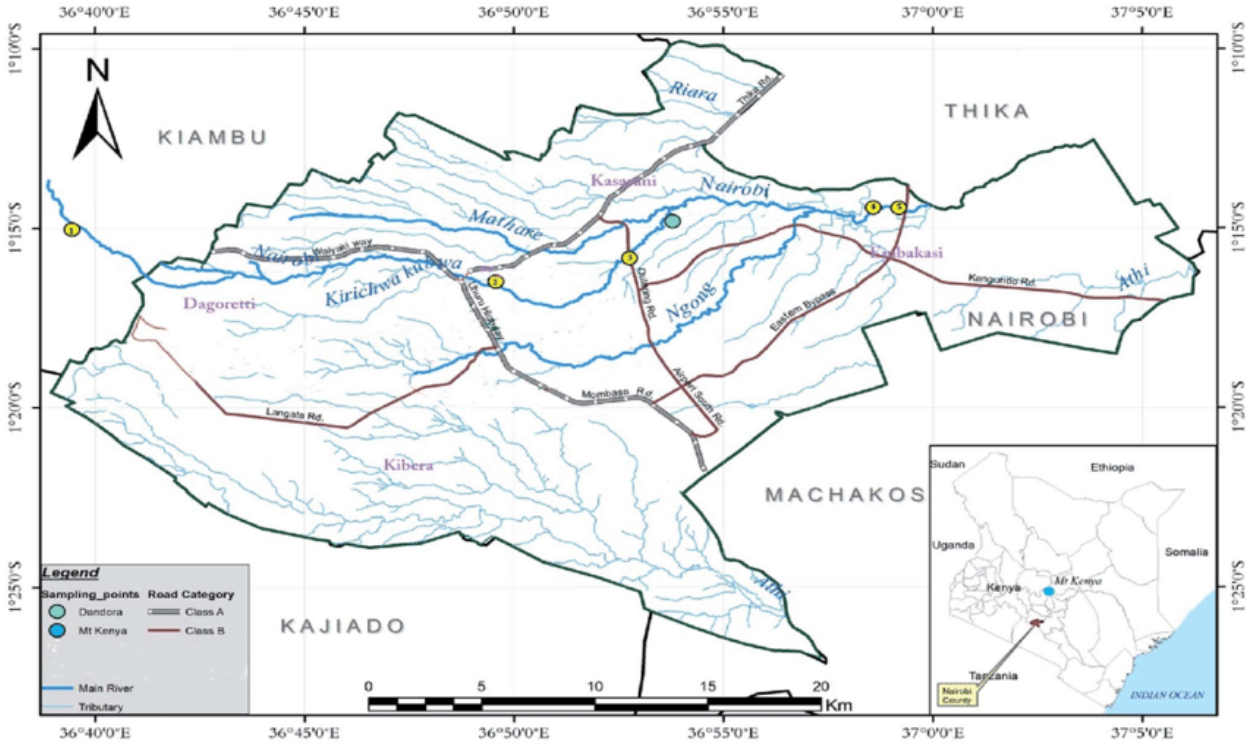
Abstract- The earliest civilizations were made possible due to settlement along major rivers that allowed for irrigation. In modern times, most of the world's major cities are built along major rivers. They provide water for drinking, sanitation, fishing and for recreation activities. Irrigation consumes well above 70% of the earths fresh surface waters which comprise of less than 1% of the global fresh water capacity. The millennium development goals had set targets which were not met and the contemporary sustainable development goals were set to realize the goals. Water is addressed on most of the SDGs goals: life under water, zero hunger etc. To achieve the above goals, there must be changes in our production and consumption patterns. Majority of pollution to the river is from human activities. Contamination is chemical, physical or biological and ultimately affects the same people as they consume water or products derived from the river. Majority of the Nairobi river has been contaminated to the point of pollution and the trend is expected to have an increase. The population is exceeding the threshold and infrastructure can't keep up. The demand for food and sewerage services are among the most polluting factor to the river. There have been efforts to rehabilitate the river bot by the county and national government. The private sector is also trying to help in the rehabilitation process.

Index Terms- SDGS, COD, ORGANIC POLLUTION, PHYTOREMEDIATION, HEAVY METALS

I. INTRODUCTION

The Nairobi river and all its peripheral streams cut through Nairobi county and into the capital city, Nairobi. It is the main river in the Nairobi river basin, a complex of several parallel streams flowing eastwards. The other main rivers are Ngong river, Mathare river and Motoine river. All these rivers join at the eastern side of Nairobi and join the larger Athi River. They river eventually flows to the Indian Ocean. These rivers are typically narrow and highly polluted. Nairobi river, the main stream, bounds the northern city center and is partially canalized. The river lies between 1°11'59"S and 37°9'26"E.



The river passes through a range of different land-use systems. It also has different vegetation as it passes through areas with varying climates. At the beginning, there are agro-ecological zones which range from humid, through semi-humid to semi-arid lands. However, land use patterns are dependent on rainfall patterns, topography and economic ability. After the agricultural use, the river enters through residential areas[1]. Increase of population and construction of houses has increased the volume of domestic effluents in the river. This has reduced the quality of water. Finally it cuts through an industrial park in the city where it is subjected to more effluents from the industries.

II. Pollution in Nairobi River

Studies on the various tributaries of Nairobi River and basin conducted in the 1990s showed Evidence of high levels of chemical and organic pollution. Ngong, Mathare and Nairobi Rivers pass through high human settlement areas. As a result, these rivers have been heavily polluted resulting to loss of good water qualities and biodiversity. Raw sewage from informal settlements and discharge from industries are main polluters of Nairobi River. Other key sources are incidences of burst/blocked sewers and solid waste discarded into the river and excessive levels of heavy metals. These are a threat to humans utilizing the water for domestic and agricultural purposes. They lead to increased COD leading to anoxic conditions in water and sediments. Continued water pollution has led to: Health problems, stress on immediate aquatic ecosystems as well as downstream, reduction of the economic value and its natural beauty. The study's main objective is to determine the status of Nairobi River downstream, and establish a baseline for monitoring water quality improvement efforts.

III. Sources of pollution

- Seepage from garbage sites
- Medical waste
- Industrials effluents
- Agro-chemicals
- Solid waste
- Raw Sewerage
- Storm water run-off

Seepage from garbage sites

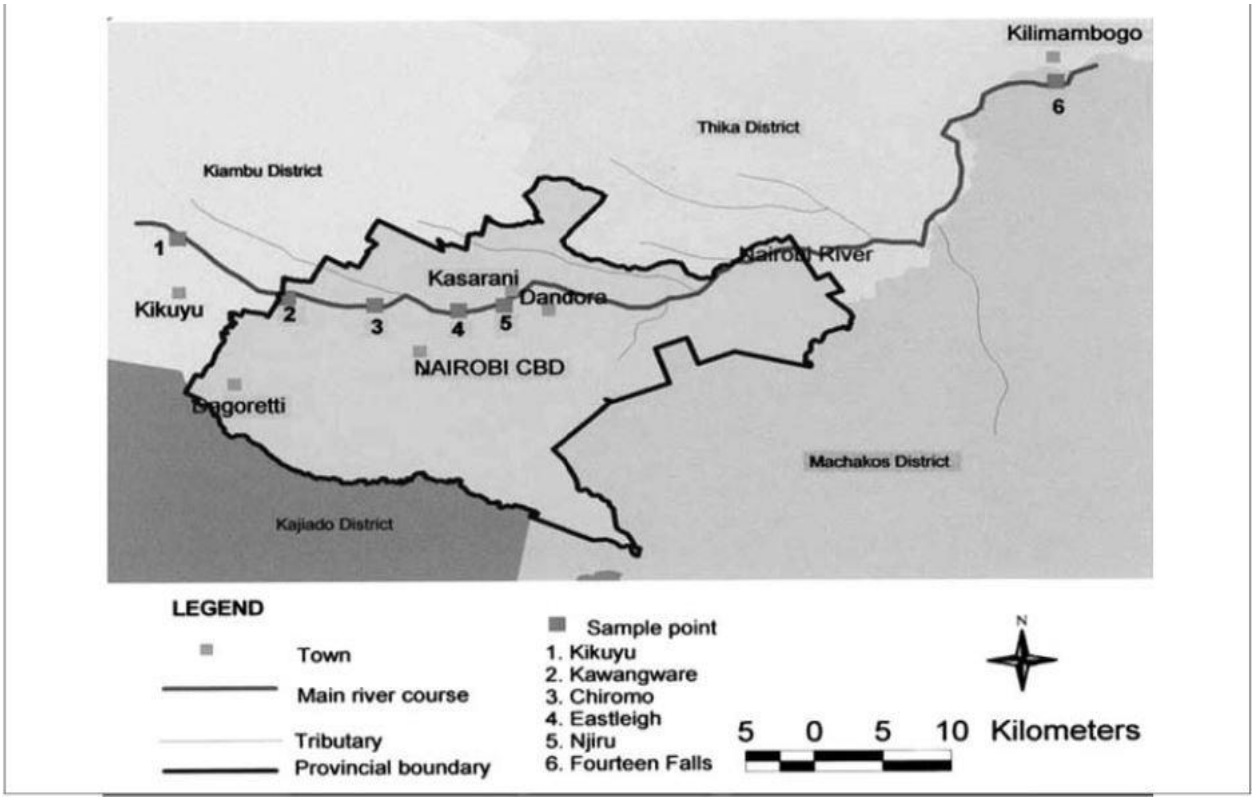
Garbage collection in Nairobi city is not regular and efficient. Only half of the waste produced daily makes it to designated dumpsites all the waste is taken to Dandora dump site.it is an opened dumping site that was previously used as a quarry

Google map Image showing Dandora dump site

The close proximity of the river to the dumpsites makes it a victim of seepage from the waste. The dumpsite produces large volumes of leachate especially during the rainy season. The leachate finds its way into the river and increases the concentration of metals and organic load in the river. Little or no effort has been done to address the problem. This contaminants are of environmental and health concerns.

Industrial wastes

The river passes through an industrial park and an informal industry known as Jua kali. The industrial area is notorious for releasing untreated effluents into the river. The industries vary in operation from metal works to food processing plants. A studied was carried out to identify the particular metal pollutants and offer a solution for their removal. The experiment was resting the phytoremediation as an alternative to conventional removal methods. Six sampling sites along the Nairobi river were determined: Kawangware, chromo, kikuyu, Gikomba, Njiru and fourteen falls.



The primary objective was to identify the extent of heavy metal pollution and potential of some phytoremediants. Copper (cu), cadmium (cd) and zinc were selected to be identified in the water, soil and plants[2]. Concentration of copper was fairly the same in all sampling sites, zinc was the most abundant followed by cadmium. Industrial discharge was identifies as one cause of the increased cadmium in the river[3].

Site	Cu	Zn	Cd
1	17.15 ± 0.5	30.58 ± 2.6	21.58 ± 0.8
2	18.35 ± 0.2	40.38 ± 3.8	25.78 ± 1.8
3	23.25 ± 0.8	39.54 ± 4.5	37.85 ± 4.5
4	28.65 ± 1.2	85.64 ± 5.6	40.35 ± 5.6
5	25.65 ± 0.3	80.54 ± 6.2	36.28 ± 2.5
6	25.65 ± 1.5	70.95 ± 4.8	28.69 ± 1.2

Mean±standard deviation, n=10 key: Cu- copper, Zn- zinc, Cd- cadmium

The concentration of the metals was observed to have reduced at the last point of sampling. They may have settled in the soil or absorbed by aquatic vegetation.

Raw sewerage

Majority of the people living in Nairobi stay in the slums or heavily congested middle-income area. Nairobi city has a population of just above 4 million people. 56% live along the river basin and majority of the areas are slums. The low incomes are characterized by poor sanitation facilities[4]. A survey conducted showed informal settlements along a small stretch (5km) of the Ngong River
Riparian has 6,800 inhabitants. This population puts pressure on available sanitation services to the point where they end up breaking down.

Image showing a burst sewage system

The picture above shows a sewerage system burst. All the waste eventually find their way into nearby rivers and streams. This is an environmental and health hazard[5]. More than 75% of the houses in Nairobi are not connected to the sewer system. Majority of them use septic tanks which are poorly maintained. Nairobi river suffers from deteriorating water quality due to rampant population increase. A slow economy and social disparities led to the mushrooming of slums, which are typically near or on the river basin. Lack of proper hygiene habits and non-existent sanitation facilities are another typical characteristic of Nairobi slums. Downstream communities are left to bear the cost of the pollution. Lack of fair government support and little environmental awareness has left the city residents with a deteriorating Nairobi river.

Solid waste

Nairobi county government is only able to transport half of the solid waste generated per day in Nairobi. The rest are dumped in illegal sites which happen to be very or just on the river banks. Majority of this illegal dumps are found within the lower income communities. The government has been trying to cover all residents but poor planning has always set back the projects[6]. The county has very few vehicles specialized to carry solid waste to designated points.

Image showing illegal dumping near Nairobi river

During the long rains early this year, there was massive flooding in the city. Few efforts had been made to mitigate the possible disaster that was looming. Despite warning from the government, people who live close to the major River declined request to vacate. The rainfall was heavy and quickly sent many waste to rivers clogging systems. The resulting flooding was responsible for a couple of deaths. People drowned and some building collapsed causing many fatalities. The government was quick to introduce a ban on single use plastics that are a very common component of solid waste. There are plans to ban plastic bottles in the near future.

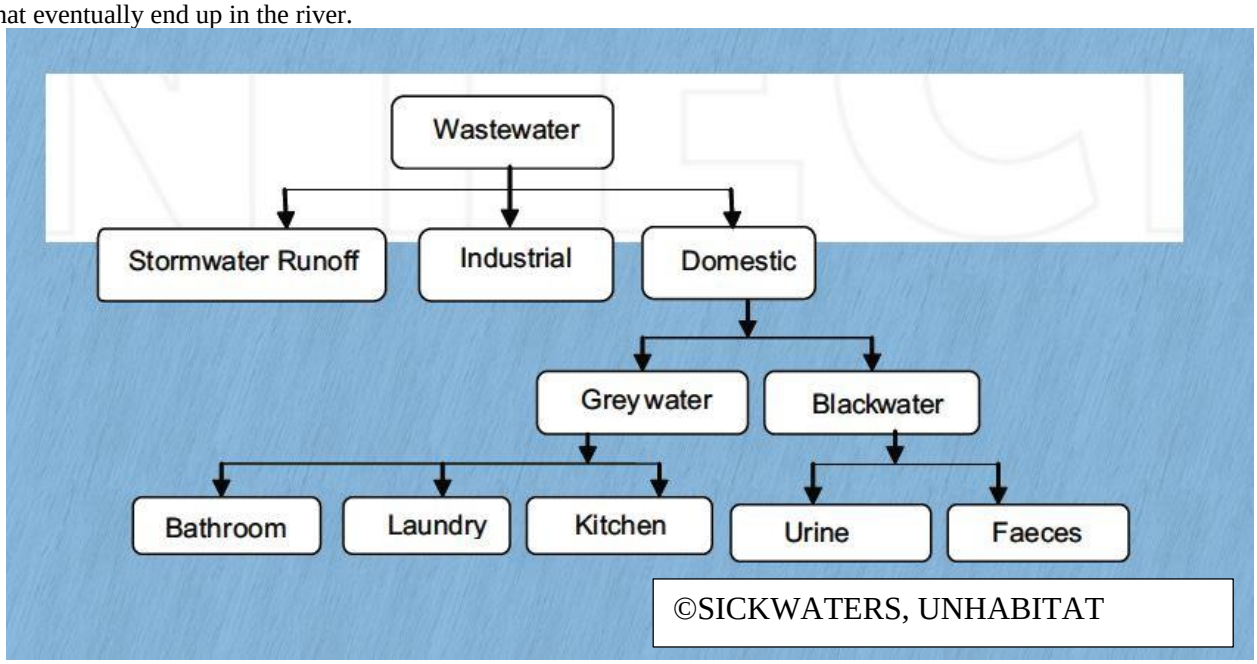
The Nairobi River passes through Kiambu County before passing through Nairobi city. Kiambu County is predominantly an agricultural area although rampant urbanization is catching up. Coffee is the major cash crop and is located along the river valleys. Chemical, pesticides and fertilizer, eventually find their way into the river[7]. As the gap between the rich and poor increases in the city, residents are forced to farm near the river to increase their income. Nearly all the banks that don't cut through estates are dominated by agricultural activities. The crops appear to be very attractive on site. However, there is concern about the water that issued. Besides adding pesticides to the river, they absorb other waste e.g. heavy metals and other clinical waste

Agro-chemicals

Image showing agricultural activities in a section of Nairobi

Waste water characteristics

The waste water from Nairobi city is predominantly from domestic households. Majority of the effluent is black and grey waters that eventually end up in the river.



The composition of the wastewater is a function of the uses to which the water was submitted. These uses, and the form with which they were exercised, vary with climate, social and economic situation and population habits. In the design of a WWTP, there is normally no interest in determining the various compounds that make up wastewater. This is due, not only to the difficulty in undertaking the various laboratory tests, but also to the fact that the results themselves cannot be directly utilized as elements in design and operation. Many times it is preferable to utilize indirect parameters that represent the character or the polluting potential of the wastewater in question. These parameters define the quality of the sewage, and can be divided into three categories:

- Physical,
- Chemical and
- Biological parameters.

Physical properties to be assessed include:

- Temperature
- Turbidity
- Color
- Odors

Chemical properties of waste water include;

- Total suspended organic and inorganic substances
- Suspended and dissolved
- Settle-able solids

Biological properties of waste water include;

- Bacteria
- Protozoa
- Archaea
- Virus
- Helminthis
- Algae
- Fungi

The world is facing a global crisis on water demand and use. Increased population, intensified agriculture and rapid industrialization are the main actors extracting water from the environment. The increased unregulated discharge of waste waters in water bodies is further increasing pressure on the water. Water is particularly a matter on global concerns because it will cross beyond national boundaries of states. The current threat is affecting human health and wellbeing with both immediate and long term consequences. Developing countries are worst hit because of the poverty levels in their economy. Ecosystem services are reduced and may at times affect other animals within the ecosystem, not humans alone. The world is taking notice of the damage caused on freshwater and marine ecosystems by humans. The current sustainable goals are addressing the water crisis in a more holistic approach. Respecting life under water, climate action and hunger reduction are some of the aspects closely tied to water resources.

The United Nations projects global population to exceed nine billion by 2050. Urban populations are expected to rise twice as fast and will have a greater population dwelling in slums. Contemporary agricultural methods extract about 70% of the available fresh water. Majority of this water finds its way back into the environment with additional nutrients and contaminants. The

waste water contaminates both freshwater and coastal ecosystems, threatening food security, safe drinking and bathing water. This eventually provides a major health and environmental management challenge[8]. A study by WHO and UNEP estimated up to 90% of wastewater flows untreated into coastal zones contributing to growing marine dead zones. The estimate of dead zones at the time was 245000km². Developing nations are hindered to increase development by increasing costs of healthcare and lost labor productivity. Close to half the population from developing countries have no access to adequate sanitation. WHO estimates that nearly 1.8 children die every year due to water related diseases.

Poor and aged wastewater infrastructure is already overwhelmed. Population increase and climate change are projected to further increase the intensity of consequences[9]. Without proper infrastructure and management, many millions of people will continue to die each year and there will be further losses in biodiversity and ecosystem resilience. This may undermine the current goal to a more sustainable future. Urgent global action is required to afford a sustained investment to improve wastewater management.

IV. Discussion.

Nairobi River has been facing numerous challenges since the settling of the British and Indians in Nairobi. The Maasai community, who are the previous occupants, referred to the river as cool waters[10]. True to their saying, the British preferred Nairobi because of the river. Traditional economic system had little or no impact on the riverine ecosystem Kenya shifted fast to allow for development projects. Housing is the most rampant form of development in Nairobi today. The houses increase pressure on the current water and sewerage systems and breakdown is only a matter of time. The city as initially designed to have a currying capacity of 300,000 people but the current population is estimated to be 4 million. This population boom only increases pressure on the system which is not as quick to catch up with the pressure.

The government has tried to use the current infrastructure to maximize their usage. International communities have been very helpful to provide technical and capital assistance to the river. Many studies have been made on and along the river to provide data for better decision making. The government has also increased pressure on Nairobi residents to reduce pollution on the river.

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