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Analysis of Total Petroleum Hydrocarbons in Water from Ngong and Mathare Rivers, Nairobi County, Kenya

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ABSTRACT

Unsustainable industrial development has created negative impacts to global ecosystem quality and biodiversity due to increased load of chemical and biological contaminants released into environment. Ecological sustainability of Nairobi River Basin in Kenya, hangs in the balance between socioeconomic exploitation and environmental management. Nairobi, Ngong and Mathare rivers constitute the three main tributaries of Nairobi River Basin. The basin has witnesssed increased pollution load, destruction of the wetlands and encroachment of the buffer zones due to rapid urbanisation. The objective of this study was to investigate the extent of total petroleum hydrocarbons (TPH) contamination in Mathare and Ngong rivers. We collected water from eight sampling sites constituting the upstream, midstream and downstream of the two rivers. The samples were extracted using HPLC grade dichloromathane and analysed for Total Petroleum Hydrocarbons (TPH) using a Gas Chromatography equipped with Flame Ionisation Detector. TPH in Mathare River ranged from 59.66±8.64 to 463.92±2.63 µg/L, whereas levels in Ngong' River ranged from 11.85±0.10 to 1,219.95 µg/L. The concentration increased downstream indicating the influence of industrial and urbanistion on the pollution load. The results suggest that industries and municipal activities in the City are contributing to TPH contamination in the Nairobi River Basin tributaries and therefore they are likely to jeopardize ecological quality of the rivers ecosystems if protective measures are not taken.

Keywords: *Nairobi River Basin, Ngong River, Mathare River, TPH, Water Pollution*

I. INTRODUCTION

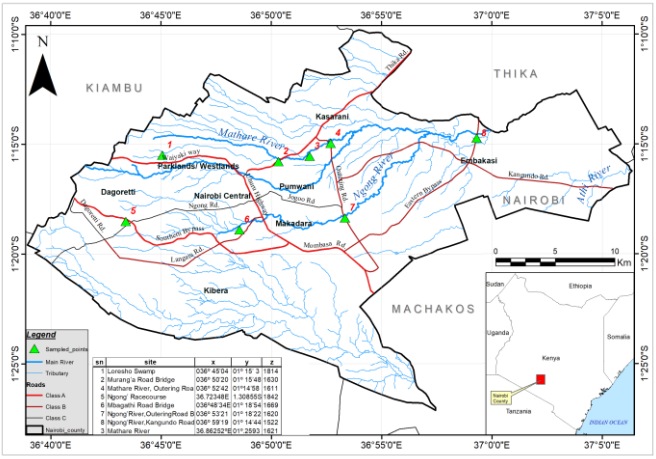
Total petroleum hydrocarbons (TPH) present a global evironmental challenge due to widespread contamination of soil, water and sediments[1,2,3]. TPH consist of hydrocarbons, from a wide variety of chemical compounds with different polarities, emanating from fatty material of biogenic origin or mineral oil[4].The physical chemicals characteristics of the individual hydrocarbons present in water and soil or sediments depend on the source such as gasoline, diesel, kerosene, fuel oil, mineral oil or asphaltic material. Whereas TPH is not generally inferred to as toxic waste, but to some extent exhibit some degree of resistance to biodegradation in the soil[5,6]. Weathering of crude oil in water is also a factor that needs to be investigated[7]. Upon introduction of hydrocarbons into the environment, several processes

occur at the area of contamination. These include physical, chemical and biological processes and infiltration into the ground water[8,9]. Part of the TPH may also undergo degradation, breaking away from the initial mixture, part may vaporize into the air[10,11] while other fraction may bind to the soil and accrue over a long time. The health effects of TPH is influenced by factors such as the type of chemical compounds in the TPH, exposure period, and the amount exposed to. Some compounds in TPH such as benzene, toluene and xylene can affect the central nervous system, while n-hexane can cause peripheral neuropathy when inhaled in high levels[12]. Some TPH fractions can also affect the blood, immune system, liver, spleen, kidneys, developing fetus and lungs[12]. There is inadequate data on the extent of TPH contamination in the Nairobi River Basin. This study sought to investigate the impact of industrial activities and urbanisation on water contamination by TPH in Mathare and Ngong River tributaries of the Nairobi River Basin.

II. MATERIALS AND METHODS

A. Study area

Four sampling sites were selected along each river, distributed to cover the upstream, midstream and downstream. The sites along Mathare River included Loresho swamp (01º 15' 30" S; 036º 45'04" E) which represented the upstream of Mathare River, Outering Road Bridge (01º14'58S and 036º 52'42E) represented the downstream. Ngong racecourse (01º 18'54" S; 036º48'34" E) represented the upstream of Ngong' River, while Kangundo Road Bridge (01º 14'44" S; 036º 59'19" E) represented the downstream. Figure 1 shows location and distribution of the sampling sites.



B. Sample collection:

Sampling was done on a monthly basis from the month of January to May 2014 covering dry and wet seasons. A total of 3 samples of water were collected from each site, making a total of 120 samples over the five months period. The samples were extracted using HPLC grade dichloromethane. 1 Litre of the sample was transferred into a separatory funnel and extracted with three portions of 60 ml dichloromethane. Gas chromatography/Flame ionization detector was used for analysis of TPH[13]. Sodium sulphate was added to facilitate drying of sediments and ground to fine powder until free flowing, prior to extraction with 80 ml dichloromethane. The extracts were reduced to approximately 1 ml and cleaned by passing through a chromatographic glass column of dimesions 25cm x 2.5 ID, packed with 10 cm neutral silica powder and anhydrous sodium sulphate.The column was washed with 20 ml hexane. 1 ml of the extract was introduced at the top of the column and eluted with n-hexane. The cleaned sample was concentrated and made to 1 ml before analysis using Gas Chromatography with Flame Ionisation Detector (GC-FID).

C. Chromatography conditions:

GC-FID oven Program: The initial column oven temperature was set at 35 °C and held for 5 minutes, then ramped to at 10 °C/minute to 250 °C and held for 10 minutes. The autosampler injection volume was 1µl splitless injection mode. GC separation was

effected on a DB wax capillary column of dimensions of 30 m x 0.25 mm ID and 0.25 µm film thicknes. The carrier gas was helium N6 grade at a flow rate of 1 ml per minute while whitespot nitrogen was used as the make up gas. Hydrogen and air were used as fuel gases. FID temperature was maintained at 300 °C, while the injection port temperature was 250 °C.

III. RESULTS AND DISCUSSION

A. Calibration:

Calibration standard for TPH was prepared from a 1:1 mixture of gasoline and diesel which was acquired from a commercial gasoline station. 0.10 g of the mixture was diluted to 10 ml using dichloromethane. Concentration range from 10 ppm to 5,000 ppm was prepared and used for calibration of the instrument. The gasoline and diesel fingerprint chromatograms were used for qualitative and quantitative determination of TPH compounds.

B. TPH in Mathare River:

The mean TPH concentration was 224.18±8.12 µg/L, whereas the median concentration was 221.91 µg/L. The overall concentration ranged from 59.66±8.64 to 463.92±2.63 µg/L. The highest concentration was recorded at Outering Road Bridge (Figure 2), whereas the lowest concentration was recored at Loresho Swamp (200.34±2.74 µg/L). Murang'a Road Bridge (Midstream) and Outering Mathare Bridge (Downstream) recorded the highest mean values of 222.21±2.74 µg/L and 286.60±1.79 µg/L, respectively. The high concentration at Murang'a Road Bridge counld be attributed to carwash activities in the suurrounding area. In addition, the location of the two sites along the busy highways increased the potential for TPH contamination through emissions.

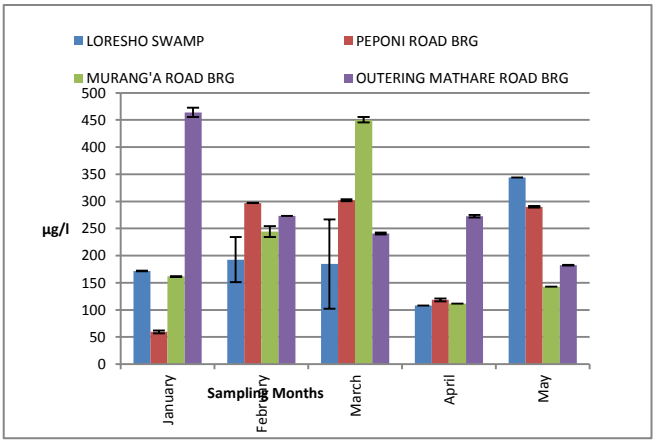


Figure 2. concentration of TPH in water of Mathare River

The overall mean of TPH in the 4 sites of Mathare River was 230.64±8.11±µg/L which is above the standard value of china's Marine Monitoring Standard of GB 3097-1997 (50 µg/L) suggesting a high risk of TPH exposure to aquatic organisms.

The higher levels observed downstream could also be attributed to oil spills and disposal of waste and sewage into the river[14]. This TPH concentration range was similar to other studies that were done in the Sea water of Bohai bay China which reported concentration range of 23.70-508.00 µg/L[15].

1) C. TPH levels in waters of Ngong River:

TPH levels varied from 11.85±0.10 -1,219.95±1.83 µg/L. Ngong Racecourse recorded the lowest concentration (57.93±0.01 µg/L) while Kangundo Road Bridge had the highest level (394.84±1.83 µg/L). This could be attributed to the fact that Ngong' Racecourse is located at the upstream of the river with minimal pollution, while Kangundo Road Bridge is located at the downstream and experiences the impact of pollution from informal settlements and business activities such as garages, petrol stations in the nearby areas such as Kayole, Donholm and Buruburu. The high concentration measured downstream (Ngong River Outering Road Bridge) could be attributed to industrial activities and informal settlements. Seasonal variation ranged from 78.98±1.05 to 256.10±20.10 µg/L in dry season and 43.90±1.03 to 487.34±4.28 µg/L in wet season. Hence the wet season experienced higher contamination

load suggesting overflow and drainage from the human activities (Figure 3).

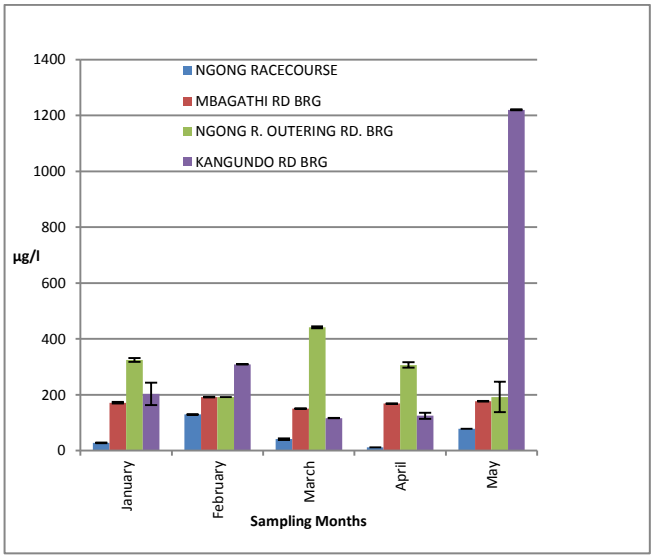


Figure 3 Concentration of TPH in water of Ngong' River.

IV. IV. CONCLUSION

This study demonstrated that there is pollution due to petroleum hydrocarbons discharge into Ngong and Mathare Rivers. The changes in TPH concentrations revealed spatial and temporal trends suggesting that the two river systems receive pollutants from both point and non-point sources. The mean concentration of TPH in Ngong River was higher than Mathare River, suggesting higher contamination load in the former. In addition, the increase in contamination from upstream to downstream suggest the critical contribution of anthropogenic sources such as industrial and municipal activities. Hence effort to restore the rivers ecosystems should address reducing discharges from anthropoginic activities.

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