Anthropogenic Impacts on Flow Regime and Water Quality of Ngong River in Nairobi

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ABSTRACT

Anthropogenic (human) activities have had adverse effects on rivers that flow in urban areas. Natural hydrological processes are overtaken by man's influence of water courses that lead to change in channel morphologies, increased catchment imperviousness and contamination of river water quality. This research project was designed after several extensive case studies that revealed lack of adequate information on interaction between water quantity and quality of Ngong River. A number of those research investigations indicate that the river is highly polluted and almost no information about water quantity is presented. This study looks at the interactions of river discharge, river water quality parameters, rainfall runoff and sewer/wastewater inflows at selected sampling stations within the Ngong River basin. The study identifies various land use characteristics to determine parameter values that are used to derive primary data on discharge, quality and surface runoff characteristics of Ngong River catchment. The Ngong River catchment land use ranged from rural to urban high and low density residential areas.

This thesis analyses water levels and water quality collected from five stations set up along the Ngong River and water quality of four sewer stations. This data was collected for a period of 5 months (July to December, 2006). The river stations are namely: Kibera, Nairobi Dam Outlet, Mombasa Road crossing, Outering Road crossing and Njiru Bridge. The sewer stations were located at Kibera, Enterprise road, Imara Daima and Outering Road.

The temporal and spatial variation of flow and water quality is assessed to establish the level of anthropogenic influences and rainfall-runoff on Ngong River regime.

Water levels were determined daily for a period of five months and converted into discharge by use of Manning's equation. Secondary daily rainfall data was accessed and the SCS Curve number method was used to estimate direct runoff.Water quality assessment was done for a wide range of physical and chemical water quality parameters. Microsoft Excel and SPSS were used for statistical and descriptive analysis. Results were screened against NEMA, FAO and WHO standards, and were compared across the five sampling stations in the dry and wet seasons to assess suitability for domestic and irrigation use.

Ngong River flow rates increased downstream with the lowest average flow rates experienced at the Kibera (0.09 m^3/s) and Nairobi Dam outlet (0.86 m^3/s) stations. Mombasa Road station had average flow of 5.45 m^3/s. Higher average flows were recorded downstream at Outering Road (6.28 m^3/s) and Njiru (7.0 m^3/s) stations. Ngong Kibera and Nairobi dam outlet stations losses water amounting to 324 mm and 126 mm respectively over the study period. These stations lose water which is abstracted for human use and dam storage. River flows at Mombasa road, Outering road and Njiru stations receive extra 860mm, 612mm and 591mm of water, respectively. These are water sources other than rainfall that falls within the Ngong river catchment. These stations receive water from other sources such as wastewater flows from overflowing manholes, faulty sewer lines and open drains.

The highest pollutant concentrations found in Ngong River water were heavy metals (lead and cadmium), nitrate and residues (suspended and dissolved solids). There were reduced levels of EC, Nitrates, TSS and TDS during the wet weather whilst lead and cadmium levels increased. Lead values increased in the wet season ranging from 0.39-0.46 mg/l. The heavy metal levels

recorded at all stations were below the FAO guidelines for irrigation water (5 mg/l for lead and 0.5 mg/l for Cadmium). The Ngong River overall ionic dominance pattern was found to be Na > Ca >K > Mg and Cl> HCO3. The ionic dominance pattern recommended for fresh water sources is Ca > Mg > Na > K and HCO_3 >SO_4 > Cl. Sewer inflows TSS and TDS levels were found to be decreasing during the wet weather. BOD_5 values of these sewers waters were high ranging from 103-500 mg/l. Heavy metal levels increased during the wet season with lead values ranging from 0.39-0.44 mg/l and cadmium values ranging from 0.08-0.12 mg/l. Sewer water contamination increased in the wet weather thus increasing the level of pollutants in Ngong River during rainfall periods where rivers undergo some form of self cleansing.

Frequent analysis of three water quality parameters shows that the Ngong river stations recorded increased dissolved oxygen levels with increased flow rates during the study period. Ammonia and BOD_5 levels were observed to decrease with increase in flow rates at four stations except for the Nairobi Dam outlet station. The Nairobi Dam outlet station showed increased contaminant loading even at higher flow rates.

The pollutant levels in Ngong River remain above NEMA allowable standards even though there were decreased concentrations with increase in flows. This implies that the Ngong River is able to achieve cleansing if it receives less contaminated inflows. Ngong River at Kibera station can be described as adequate since water sampled complied with WHO and NEMA standards for most parameters except for Nitrates. According to FAO irrigation water standards, Ngong River is fit for irrigation however this should be cautioned due to the long term accumulative effects on the soils and crops. Frequent water quality monitoring programs combined with the enforcement of NEMA criteria and guidelines on effluent discharges, improvement of sewer infrastructure,

protection of riparian areas, control of direct waste discharges, decreasing surface runoff distances and, the creation of pervious areas for increased infiltration, can be adopted to restore the hydrological system of the Ngong River.