Physical Chemical Parameters of Wastewater: A Case Study of Njoro Sewage Works, Nakuru, Kenya

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Abstract
Njoro sewage works is the main sewage work for Nakuru urban town that receives about 90% of industrial wastewater and 10 % domestic wastewater. In-sufficient pre-treatment of industrial wastewater, may affect the normal functioning of sewage works and the aquatic life (flora and fauna) of the receiving water body. The underground water aquifer may also be contaminated by both chemical elements and microbial through percolation. This study aimed at assessing the efficiency of the sewage works by analysing the physical and chemical parameters of wastewater from the inlet and outlet of Njoro sewage works. The study involved test analysis of the physical and chemical parameters in the laboratory and in-situ test. This study employed composite sampling method in the collection of samples. Data collection was done using experimental method while data analysis was done using descriptive statistics. This study found that BOD concentration was 400 mg/l for the influent and 150mg/l for effluent. COD concentration was 1399 mg/l for the influent and 222 mg/l for the effluent. DO concentrations were lower (0.05 mg/l) for influent and effluent. Traces of heavy metals were also found both for the influent and effluent. Njoro sewage works could not effectively reduce organic load in wastewater.
Keywords: Discharge, Effluent, Influent, Sewage works, Wastewater

1. Introduction
Water comprises over 70% of the Earth's surface making it undoubtedly the most valuable natural resource that exists on the planet, without which life would be non-existent. It is vital for everything to grow and thrive (Akali *et al.*, 2011). The global benchmark of fresh water was 1000m^{3}per capita (GOK-NWRMS, 2005-2007). Despite this, anthropogenic activities worldwide pollute water bodies leading to decrease in fresh water sources. It is estimated that nearly 1.5 billion people lack safe drinking water globally and that at least 5 million deaths per year can be attributed to waterborne diseases (Onsdorff, 1996).

Today, most of the rivers receive millions of litre sewage, domestic wastewater and industrial effluents varying in characteristics from simple nutrient to highly toxic substances. In recent years, increasing industrialization, urbanization and developmental activities with the explosion of human population leads to generation of large amount of wastewater from domestic, commercial, industrial and other sources (Majid, 2010). Anthropogenic activities have got adverse impact on the water quality of major rivers. Water quality decay is characterised by significant modification of Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Zinc (Zn), Lead (Pb), Chromium(Cr) and Total Alkalinity (TA) are as a result of discharging wastewater into the rivers. Adverse impact on the environment related to wastewater results due to unknown characteristics of wastewater being discharged to the environment especially to the water bodies. Therefore, it is very significant to analyse the characteristics of wastewater so as to prevent and control pollution of water bodies and environment.

Njoro sewage works is the main sewage work for Nakuru urban town that receives about 90% of industrial wastewater and 10 % domestic wastewater. In the year 1995 the sewage works was rehabilitated due to increased wastewater capacity in Nakuru Town. In-sufficient pre-treatment of industrial wastewater, may affect the normal functioning of sewage works and the aquatic life (flora and fauna) of the receiving water body. The underground water aquifer may also be contaminated by both chemical elements and microbial through percolation. This study aimed at assessing the efficiency of the sewage works by analysing the physical and chemical parameters of wastewater from the inlet and outlet of Njoro sewage works. Proper wastewater treatment is necessary for promoting public health and ecosystem survival.

2. Literature Review
Physical characteristics of wastewater include odour, gray colour, turbidity and solid content of almost 0.1%. Biologically, wastewater contains various micro-organisms, protista (bacteria, fungi, protozoa and algae), plants and animals. Toxic compounds generated by the protista are found in wastewater (Punmia and Jain, 1998). Chemically, wastewater is composed of both inorganic and organic compounds as well as various gases. Inorganic compounds include heavy metals, nitrogen, sulphur, phosphorus, chlorides among others. Organic compounds may constitute carbohydrates, proteins, fats, greases, oils, pesticides, phenols among others. Wastewater contains a higher portion of dissolved solids than suspended, about 85-90% of the total inorganic

component is dissolved. About 55-60% of the total organic component is dissolved. Gases dissolved in wastewater are hydrogen sulphide, methane, ammonia, oxygen, carbon IV oxide and Nitrogen (Jhanis and Mishra, 2013). Inorganic industrial wastewater is produced mainly in the coal and steel industry, non-metallic minerals industry, commercial enterprises and industries for the surface processing of metals (iron picking works and electroplating plants) as indicated in table 2. These wastewaters contain a large proportion of suspended matter which can be eliminated by sedimentation, often together with chemical flocculation through the addition of iron or Aluminium salts, flocculation agents and some kind of organic Polymers (Henze, 1992).

Industrial wastewater contains organic industrial waste flow from the chemical industries and large scale chemical works which mainly use organic substances for chemical reactions. Most organic industries wastewaters are produced by factories manufacturing pharmaceuticals, cosmetics, glue and adhesives, tanneries and leather factories, textile factories, cellulose and paper manufacturing plants, oil refining factories, brewery and fermentation factories and metal processing industries (Lefebrne and Molelta, 2006). There are many types of industrial wastewater based on the different industries and the contaminants with each sector producing its own particular combination of pollutants. These wastes affect the normal functioning of sewage works or life of the receiving water body if they are not treated well from the source point (Henze *et al*., 2001). The wastewater discharged into the receiving river without treatment has discoloration, foul smell and kill aquatic life (Flora and Fauna). The water changes the chemical characteristic thus it becomes unfit for various purposes. In Nakuru town there are wet and dry industries (Table 1). Wet industries are those that use water in the production process and thereby generating wastewater as one of the final product. Dry industries do not use water in their processes but generate solid waste (Opaa and Omondi, 2012).

3. Materials and methods

3.1 Location of the Study area

The study was conducted in western zone (industrial area) and Njoro sewage works in Nakuru municipality. The coordinates for the study area located at latitude 0^{0}19’12’’, 83^{0} S, longitude 36^{0}3'43’’, 72^{0}E which is located south west of the Nakuru municipality. The wastewater from the industry is discharged through sewer-line to the sewage works and through storm drain concrete.

3.2 Physical Chemical Parameters and Methods of Analysis

The study involved test analysis of the physical and chemical parameters in the laboratory and in-situ test.

3.3 Sampling

Composite method of sampling was used to collect samples for physical-chemical and heavy metals tests. The sampling point was at the inlet of the sewage work, facultative pond, maturation pond and the outlet point to river Njoro. Samples were collected twice a day within a span of six hours (9:00am to 3:00pm) to come up with a homogenous sample as per the guidelines of (APHA, 2005). The parameters of concern determined include; BOD, COD, total alkalinity, pH, temperature, DO, TSS, TDS, heavy metals (Chromium, Copper, Zinc, and Lead). Sampling for in-situ test samples still used the composite sampling method. For qualitative analysis clean sampling bottles were used. The in-situ tests done were pH, DO, Conductivity, TDS and Temperature. The test analysis was measured using clean rinsed glassware and calibrated field equipment which were all rinsed well after every sampling. All samples for heavy metals were pre-treated (acidified) according to (APHA, 2005). The samples were marked properly and stored in a cool box and then taken to Rift Valley Water Services Board (RVWSB) laboratory and Nakuru testing laboratory (NAWASCO) for analysis. Samples for BOD were analyzed immediately and the rest were refrigerated and analyzed within the recommended conditions.

Sampling sketch map: The sampling points for the inlet and outlet are indicated in the schematic diagram figure 2. Two samples for each site were collected at interval of 6 hours and mixed to make one homogenous sample for a period of 4 weeks.

3.4 Data collection

Experimental method was used to collect analytical data on the concentration of parameters for the determined sampling points which involved the physical, chemical and selected heavy metals from the inlet and outlet of Njoro sewage works. Conductivity, Total Dissolved Solids, Dissolved Oxygen and pH was done on site (in-situ test). The measurements were digitally read direct from the field equipment. The chemical and heavy metal sample analysis were conducted according to guidelines provided (APHA, 2005) and the Atomic Absorption spectrophotometer (AAS) operating Manual. The method was spectrophotometric of which every test was done at specific wavelength as provided by the equipment manual. The influent to the sewage work and effluent of the ponds wastewater characteristics was each determined through a series of standard tests according to (APHA, 2005). This also included the sample preparation for analysis, standards and storage of samples.

Biological Oxygen Demand: Biological Oxygen Demand was done using Oxitrop equipment. The equipment has got dilutions indicated on the machine. The volumes depend on pollution level and the sample were measured and put in the Oxitrop bottles. Then the tube was inserted to the bottle and 1 to 2 Sodium Hydroxide pellets was put in the tube. Analysis was done at 20^{o}c for 5 days. The equipment computes the reading daily at controlled temperature.

Chemical Oxygen Demand: The analysis of COD followed the Hach method procedure manual. The reagents were supplied pre-prepared and analysed according to the organic load. The reagent range from low, medium and high ranges. Sample of 10mls was put in the specific range of reagent and digested for one hour in the heating block, then left to cool before subjecting to the COD reader which automatically indicates the reading digitally.

Total Alkalinity: The Total alkalinity was done using titrimetric method (APHA, 2005). Stock solution of 0.1N was prepared concentrated sulphuric acid and the 0.02N standard was made from the stock and used as titrant. Methyl orange indicator method was used in the titration.

pH: The pH was digitally done by use of a calibrated pH meter using buffers for accuracy. Measurements were read directly from the meter. All pH parameter was done on site.

Temperature: The units for temperature were ^{0}C. Tests were done during sampling. The equipment displayed temperature for specific sample.

Dissolved Oxygen: The samples were tested using digitized equipment which has self- controlled temperatures.

Total Suspended Solids (TSS): First the filter paper was dried in the oven for 60 minutes and then cooled for 30 minutes. The filter paper was then weighed and the weight recorded. The weighed filter paper was then put in a membrane filtration unit and wetted with distilled water. Measured 100mls of sample and poured into the filter paper, suctioned the sample and completely rinsed the side of the filter holder. The filter paper was dried in the oven for 103^{0}C for 60 minutes, cooled for 30 minutes and then weighed. The weight of the TSS is got by subtracting the weight of the filter paper before filtration from the weight of filter after filtration.

Weight of TSS in sample (A) =weight of filter with dried sample - (Minus) weight of filter

mg /l TSS = A×1000 ÷volume of sample used.

The analysis was according to (APHA, 2005).

Conductivity and Total Dissolved Solids (TDS): The test was done using automatic compensation temperatures equipment corrected to 25^{o}C.

Heavy metal: The heavy metal (Cr, Pb, Cu and Zn) analyses were done using Atomic Absorption spectrophotometer.

The samples were pre-treated immediately after sampling on site by adding 0.5 ml of conc. HNO_3. Samples were digested by adding 5ml HNO_3 to the 100ml sample of the treated sample. The sample was digested until it remained about 15-20ml. The digestion method was mild and this applied to all heavy metal analysis. The equipment procedure followed the guidelines provided by the AAS manual and APHA, 2005 procedures. Standards for each metal were prepared from specific stock solution. The standards were of range 0.0, 2.0, 4.0, 8.0, 10.0. Analysis was done for each specific metal at the right wavelength. The concentrations were calculated by means of calibration curve which is displayed by the AAS.

The specific element was determined by aspirating the sample in the flame of the atomic Absorption spectrophotometer. The element is normally converted to atomic state by thermal dissociation. The absorption of the atoms was measured at the beam path at wavelength of the specific element being analysed. Also the hollow cathode lamp for specific element was used.

3.5 Data analysis

Microsoft software excel was used to analyse the data. Descriptive statistics was also used to organize and manage the data.

4. Results

Physical chemical parameters of the inlet and outlet of Njoro sewage works water samples were collected weekly. Table 3 shows the mean concentration of physical chemical parameters of inlet and outlet of Njoro sewage works. While, table 4 indicates the mean concentration for heavy metals.

4.1 The Acidity (pH)

Generally, the wastewater collected from the inlet and outlet of Njoro sewage works in the weeks were slightly alkaline. The pH ranges from 6.99 to 8.50 with an average of 7.89. Thus the pH values of wastewater were within the acceptable range given by NEMA Standards which is 6 to 9.

4.2 Conductivity

The conductivity level of the influent was higher (620 µS/cm) in the second week and lower at the fourth week (363 µS/cm). The conductivity level of the effluent was higher (120 µS/cm) at the third week and the lower conductivity level at the first week.

4.3 Total Dissolved Solids
The TDS concentration of the influent was higher (1030 mg/l) on the third week and lower on the fourth week (740 mg/l). TDS concentration of the effluent was higher (1110 mg/l) on the first week and lower (750mg/l) on the fourth week.

4.4 Temperature
Lower temperature was observed at the inlet and outlet of Njoro sewage works in the second week. Higher temperature was observed at the outlet of Njoro sewage works in the first week.

4.5 Total Suspended Solids
The TSS concentration of the influent was higher (620 mg/l) on the second week and lower on the fourth week (362 mg/l). TSS concentration of the effluent was higher (120mg/l) on the third week and lower (93 mg/l) on the first week.

4.6 Total Alkalinity
The TA concentration of the influent was higher (1568 mg/l) on the second week and lower on the third week (888 mg/l). TA concentration of the effluent was higher (1568 mg/l) on the second week and lower (690 mg/l) on the fourth week.

4.7 Biological Oxygen Demand
BOD concentration of the influent was higher (400mg/l) on the first and fourth week and lower on the second week (250mg/l). BOD concentration of the effluent was higher (150 mg/l) on the fourth week and lower (90 mg/l) on the second week.

4.8 Chemical Oxygen Demand
COD concentration of the influent was higher (1399 mg/l) on the first week and lower on the fourth week (450 mg/l). COD concentration of the effluent was higher (222mg/l) on the second week and lower (143mg/l) on the first week.

4.9 Dissolved Oxygen
DO concentration of the influent was higher (0.09mg/l) on the fourth week and lower on the second week (0.05mg/l). DO concentration of the effluent was higher (0.18 mg/l) on the third week and lower (0.05 mg/l) on the second week.

4.10 Lead
Lead concentration of the influent was higher (0.0783mg/l) on the first and second weeks and lower on the third week (-0.2972 mg/l). Lead concentration of the effluent was higher (0.1621mg/l) on the fourth week and lower (-0.0134mg/l) on the third week.

4.11 Copper
Copper concentration of the influent was higher (-0.0114mg/l) on the fourth week and lower on the third week (-0.321 mg/l). Copper concentration of the effluent was higher (0.0238 mg/l) on the first week and lower (-0.777 mg/l) on the second week.

4.12 Zinc
Zinc concentration of the influent was higher (0.5961mg/l) on the fourth week and lower on the first week (0.1505mg/l). Zinc concentration of the effluent was higher (0.7434mg/l) on the second week and lower (0.0042 mg/l) on the third week.

4.13 Chromium
Chromium concentration of the influent was higher (2.0868mg/l) on the second week and lower on the fourth week (0.023mg/l). Chromium concentration of the effluent was higher (0.0223mg/l) on the fourth week and lower (-0.4542 mg/l) on the first week.

5. Discussion
Wastewater from Njoro sewage works is discharged into Njoro River which drains into Lake Nakuru. It is very significant to treat wastewater so as to prevent pollution and contamination of the receiving water body and the environment. Failure to treat wastewater can lead to adverse health impacts to aquatic life, ground water aquifer and the environment at large. It can also cause extinction to important species in the biodiversity. Wastewater

which is not properly treated can lead bioaccumulation and bio-magnification of heavy metals in aquatic life, which in turn affects human beings.

High pH has got an impact on the microorganisms in the wastewater treatment plants, thus impacting the performance of the wastewater treatment plant. A study by Environmental Business Specialists (EBS), (2018), indicates that the pH of wastewater has an adverse effect of the growth rate of microbial organisms. High pH affects the metabolic functions of the enzymes. Majority of microbes thrives well at pH of 6.5 to 8.5. However, at extreme pH some enzymes can do well and thrive in basic or acidic wastewater. For example fungi tolerate acidic wastewater. However, bacteria and protozoa thrive well at pH of 7. Irregular pH in wastewater treatment plants can reduce removal of organic load in wastewater thus affecting Biochemical Oxygen Demand (BOD).

A study done by Mkunde *et al.*, (2014) in Dodoma Tanzania revealed that the conductivity level of wastewater from an annual average of conductivity concentration was 1768.17µS/cm. The waste stabilization ponds managed to reduce the conductivity of wastewater by 13% to 1538.83µS/cm. This indicates that higher conductivity level of wastewater has got an impact on the effectiveness of waste stabilization ponds.

Total dissolved solids of wastewater in Njoro sewage works were within NEMA standards of 2000 mg/l. Total suspended solids of wastewater at the outlet of Njoro sewage works were within allowable NEMA standards of 250 mg/l. As the Total Suspended Solids in wastewater increase the absorption level of sunlight increases thus increases the temperature in wastewater reducing the oxygen level in wastewater hence affecting the growth of microorganisms in wastewater. A study by Chemtech International, 2017 indicates that a high concentration of TSS reduces the efficiency of wastewater treatment operation by disrupting the water balance due to increase of wastewater temperature and reducing the dissolved oxygen.

In wastewater treatment plant bacteria are useful in the breakdown of organic load in wastewater. However, higher levels of BOD in wastewater can result to unwanted amounts of bacteria. These bacteria can drain oxygen in the waste stabilization ponds which can eventually harm the aquatic life. Therefore it is significant for the industries to control the BOD of their effluent to the sewage works. This study is in line with a study done by Morrison, (2017) in Canada, which indicted that higher concentrations of inorganic solids in wastewater take longer time to breakdown and hence can cause clogging and siltation of the system thus affecting the performance of sewage works.

Chemical Oxygen Demand of wastewater in Njoro sewage works were within maximum allowable limits of NEMA standards of 1000 mgO_2/l. It is a requirement for treated wastewater to meet NEMA standards so as not to impact on the receiving water body. Higher levels of COD can be very devastating to the water bodies. It may upset the balance of oxygen in the surface water since the breakdown of organic matter uses up the dissolved oxygen. This may result to depletion of the supply of oxygen in the water needed by the organisms in the aquatic ecosystem, resulting to degradation of water quality. According to Mohamed and Mohamed, (2016), the effectiveness of the waste stabilization ponds depends on the growth of microorganisms in the treatment unit and maintenance of the environment conditions for the system to remove the excess sludge. If the influent of wastewater has got higher level of COD it will deplete the dissolved oxygen thus affecting the performance of the treatment plant.

Temperature of wastewater being discharged into River Njoro was within the NEMA allowable limits of 20-35. Discharging wastewater with high temperature may adversely affect the water ecosystem. High temperature affects the equilibrium of the environment of an aquatic ecosystem. It may lead to increased sediment build-up in a water body affecting its turbidity which may cause a rise in water temperature.

Higher level of lead observed in the wastewater of Njoro sewage works was 0.1621 mg/l. High concentration of lead can bio-accumulate in the bodies of aquatic life. This may result adverse health impacts due to lead poisoning. Health impacts of lead poisoning can take place even at very low concentrations. For instance, the body functions of phytoplanktons are disturbed by traces of lead in a water body. Lead is a very dangerous chemical since it bio-accumulate in an individual organism through food chain.

Chromium is dominant in most wastewater compared to other metal ions due to its availability in many industrial processes. There is still the scope of cost-effectiveness in the removal of Chromium and the efficiency in the treatment. Chromium is required for carbohydrate and lipid metabolism and the utilization of amino acids. Its biological function is also closely associated with that of insulin and most Cr-stimulated reactions depends on insulin. However, excessive amount can cause toxicity and the toxic levels are common in soils applied with sewage sludge. Chromium can lead to liver damage, pulmonary congestion, oedema and causes skin cancer (Biddut *et al*, 2013).

6. Conclusion and recommendation

The trends for physical and chemical wastewater parameters of the Njoro industrial sewage works from 1995 to date showed that highest conductivity, TSS, BOD concentration and COD concentration were observed during the dry season with concentration of COD during the wet and dry seasons fluctuating. The highest pH was observed in the wet season. Weekly variation of physical and chemical parameters of the inlet and outlet of

Njoro sewage works indicated that the pH level and DO concentration of the effluent was higher, Lead concentration of the effluent was higher from week 2 while Zinc concentration of the effluent was higher in 1, 3 and 4. The concentration of TDS was higher in the effluent than in the influent in week 1, 2 and 4. Further, conductivity level, Total Suspended Solids, TA, BOD, COD and Chromium concentration of the influent were higher. The concentration of Copper at the influent was undetected but there were traces of Copper at the effluent. Pink coloration was observed in the facultative and maturation ponds of Njoro sewage works.

Heavy metals that were found in the effluent of Njoro sewerage works were; Lead, Copper, Zinc and Chromium. High concentration of Chromium (2.0868mg/l), Zinc (0.7434 mg/l), lead (0.1621mg/l) and copper in traces.

The study recommends that use of wetlands should be enforced in both the industries and in the sewage works processes for efficient removal of heavy metals. Water Service Provider (NAWASCO) should monitor the influent of Njoro sewage works to ensure its effectiveness by acting on remedial measures to eliminate the presence of pink coloration in both the facultative and maturation ponds.

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Table 1. Factories connected to the public sewer within Nakuru town (MCN and NAWASSCO, 2009).

Factory	Products	Industrial sector	Effluent type
Bidco Ltd	Edible Oil	Food	Organic
Palmac Oil Refiners	Edible Oil	Food	Organic
Manengai Oil Refiners Ltd	Edible Oil	Food	Organic
United Millers	Edible Oil	Food	Organic
Happy Cow Ltd	Milk Processing	Food	Organic
Valley Bakery Ltd	Bread baking	Food	Organic
Spin Knit Dairy	Milk Processing	Food	Organic
New Kenya Cooperative Creameries	Milk Processing	Food	Organic
Palmac Soap Factory	Soap	Chemical	Organic
Menengai Soap factory	Soap	Chemical	Organic
Pyrethrum Board of Kenya	Insecticides	Chemical	Organic
Nakuru Tanners	Chrome tanning	Tannery	Organic and heavy metal
Londra Ltd	Textile	Organic and heavy metal	Organic and heavy metal
Spin Knit Textile Ltd	Textile	Organic and Heavy metal	Organic and heavy metal

The above factories are connected to sewer-line and are expected to ensure that wastewater released from their premises meet the NEMA standards so that they do not affect the operation of sewage system.

Table 2. Toxic Pollutants from industrial waste (Kumar and Pumnia, 2008)

Industry	Total pollutant
Fertilizer	Ammonia, arsenic
Coke ovens	Phenols, cyanides, thiocyanate, ammonia
Metallurgical	Heavy metals (copper, cadmium, zinc)
Iron and Steel and	BOD, COD, oil, metals, acids, phenols and cyanide
Electroplating	Chromium, copper, cadmium ,zinc
Synthetic wool	Acrylonitrite, acetonitrite, HCN
Petrochemicals and refineries	Phenols, heavy metals, cyanides BOD, COD, mineral oils, phenols and chromium
Textile and leather	BOD, solids, sulfates and chromium
Pulp and paper	BOD, COD, solids, chlorinated organic compounds
Chemicals	COD, organic chemicals, heavy metals, SS and cyanide
Non- ferrous metals	Fluoride and Suspended Solid
Microelectronics	COD and organic chemicals
Mining	SS, metals, acids and salts

Table 3. Physical Chemical Parameters

Sampling point	PH	Cond µS/cm	TDS (mg/l)	DO (mg/l)	Temp °C	TSS (mg/l)	T/A (mg/l)	BOD (mgO_2/l)	COD (mgO_2/l)
Week1									
In-let	6.99	1490	740	0.07	20.7	522	1266	400	1399
Out-let	7.80	2105	1110	0.05	21.1	65	830	100	143
Week 2									
Inlet	8.30	1720	860	0.05	19.8	620	1596	250	985
Out-let	8.51	2080	1060	0.13	19.8	93	1568	90	222
Week 3									
Inlet	7.52	2140	1030	0.07	20.0	592	888	300	500
Out-let	7.97	2030	920	0.18	20.2	120	845	93	148
Week 4									
Inlet	7.54	1470	740	0.09	20.2	362	1100	400	450
Out-let	8.5	1860	950	0.12	20.2	80	690	150	150

Table 4. Heavy metals

Sampling point	Pd (mg/l)	Cu (mg/l)	Zn (mg/l)	Cr (mg/l)
Week 1				
Inlet	0.0740	-0.1149	0.1505	0.4992
Outlet	0.0350	0.0238	0.01928	0.4542
Week 2				
Inlet	0.0783	-0.1132	0.4782	2.0868
Outlet	0.1621	-0.0777	0.7434	-0.02769
Week 3				
Inlet	-0.2972	-0.321	0.4782	1.989
Outlet	-0.0134	-0.0600	0.0042	-0.00145
Week 4				
Inlet	0.0783	-0.0211	0.5961	0.0405
Outlet	0.1621	-0.0114	0.0098	0.0223

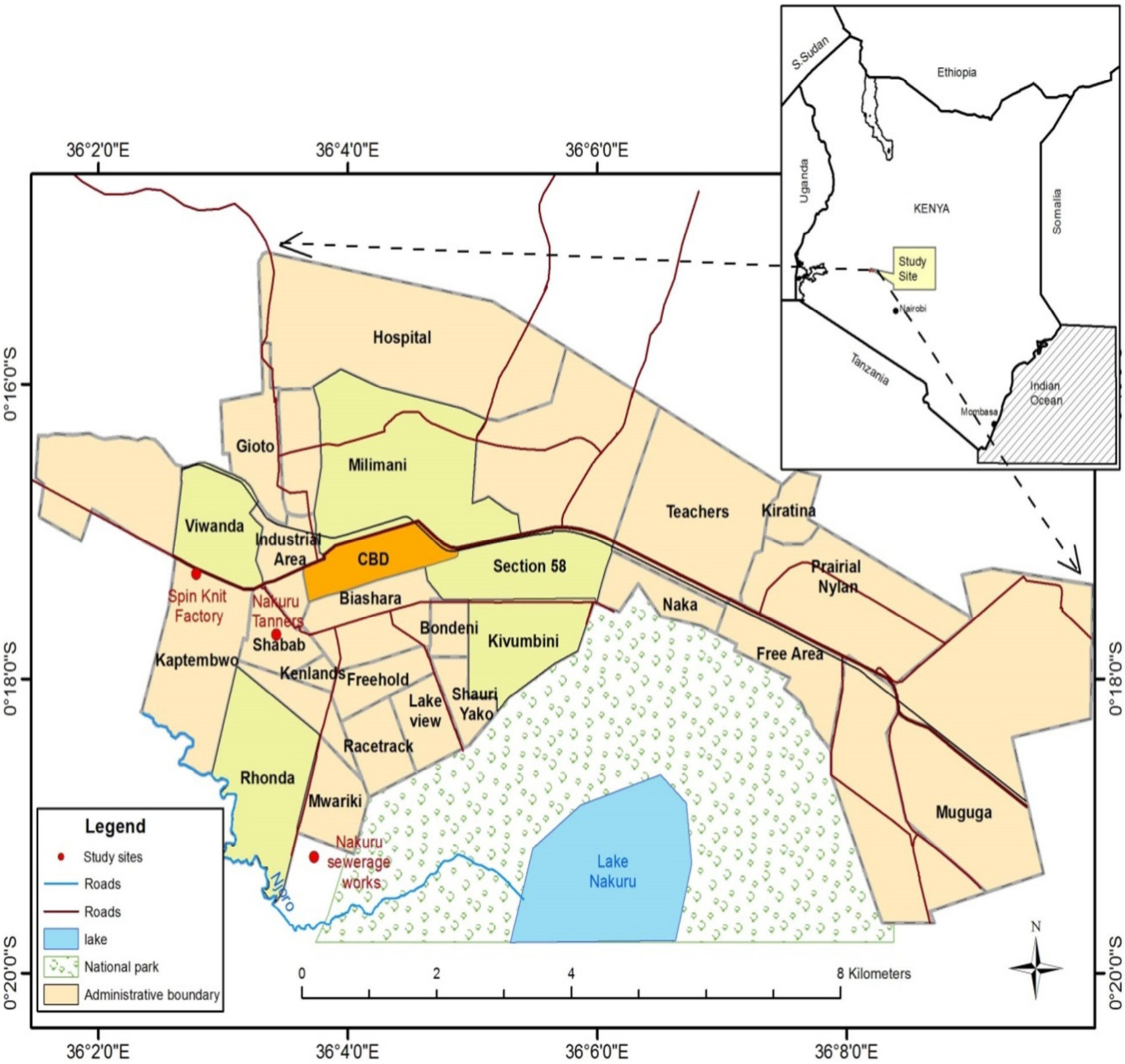

Figure 1. Study area

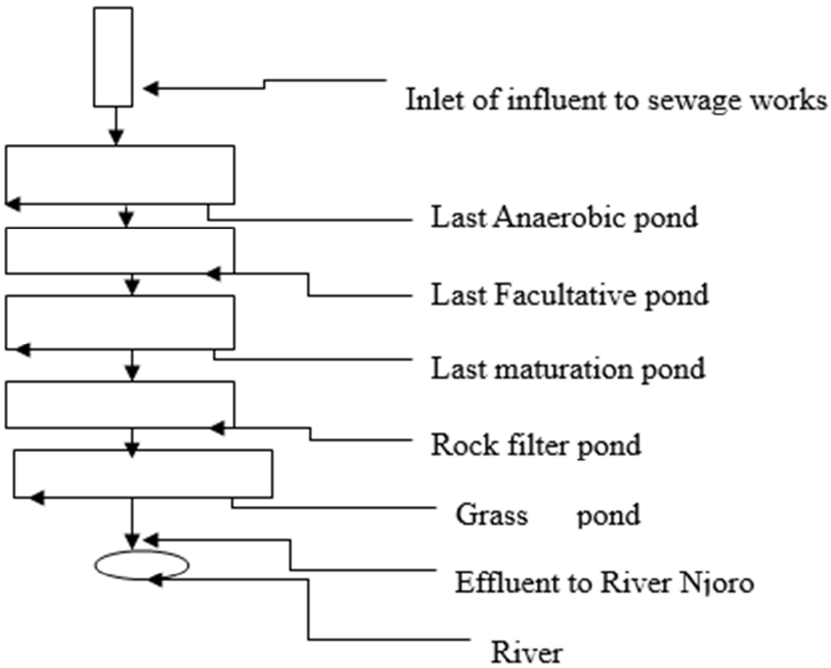

Figure 2. Sampling sketch map