Survey and Situation Analysis of the Biological Characteristics of the Main Tributaries of the Nairobi Rivers, Reservoirs and Wetlands.

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1.0 Background

1.1.1 Nairobi River Basin Programme, Phase III

The Nairobi River Basin Programme (NRBP) was started with the sponsorship of UNEP, *inter alia*, in 1999 (UNEP 2002). Phase I constituted a situation assessment of water quality, public awareness, community outreach through pilot income generation projects and capacity building. Phase II of the programme (June 2001 - December 2003) was a pilot initiative, focusing on a tributary of the Nairobi River system - the Motoine/Ngong River. It mainly involved pollution monitoring and assessment of 22 km of the Motoine/Ngong river basin upstream, the dam itself and 25 km downstream to the confluence with the Athi River. The phase also put emphasis on community education and information programmes to enable capacity building amongst key grassroots stake holders. Phase III (October 2004 - September 2008 (IUCN Pers. Comm 2005) is a follow up of the first two phases and has 5 results to be implemented, they include:

Result 1: Nairobi River Basin environmental management and urban planning systems developed and accepted;
Result 2: Restoration and rehabilitation of the Nairobi Dam,
Result 3: Water quantity and quality measuring protocols developed and tested,
Result 4: Service delivery, environmental conservation and sustainable utilization of resources enhanced, and
Result 5: Public awareness and participation in environmental issues affecting the Nairobi River Basin enhanced

The main output of phase III is encapsulated in the NRBP Vision: "a *restored riverine eco-system with clean water for the capital city and a healthier environment for the people of Nairobi."*

1.2 NRBP Phase III - Work Programme

1.2.1. Programme Objective

To rehabilitate, restore and manage the Nairobi river ecosystem in order to provide improved livelihoods, especially for the poor, enhanced biodiversity, and a sustainable supply of water for domestic and industrial, recreational and emergency uses.

1.2.2. Result Area 1:

Nairobi River Basin Environmental Management and Urban Planning Systems Developed and Accepted.

1.2.3. Output 1.1

Situation analysis of the Nairobi River Basin

1.2.4. Activity 1.1.1

Survey and analysis of physio-chemical and biological characteristics of the three main tributaries of the Nairobi rivers and reservoirs:

1.2.5. Agencies Responsible for Results, Outputs, Tasks and Activities

- **Network for Water and Sanitation International (NETWAS)**

Consolidate available data (2002) and carry out its analysis (2) Carry out a stakeholders analysis (3) Provide data on other sources of water e.g. rain water that flows into the Nairobi River Basin

- **Kenya Wildlife Service (KWS)**

(1). KWS GIS Support Service to assist with the base map of the project area of the Nairobi River Basin ; the GIS map could indicate the points of industries discharge along the Nairobi River basin-this will be done in collaboration with UoN (2). Map out different land use activities around the Nairobi River Basin (3) Contribute to data on biological system of the basin in collaboration with UoN (4) The GIS map will be used to manage the baseline data of the Basin and to prepare for the report:

- **UoN-Department of Chemistry**

Physico-chemical analysis (1) Use data obtained from implementation of Result 3 Water quantity and quality measuring protocol developed and tested of the NRBP project document (2) Consider data on water that enters the Nairobi River Basin from the Water Supply (3) Gather data on industries that discharge into the rivers-this will form part of the report:

- **UoN-Departments of Zoology & Botany**

Biological analysis (1) Analysis that has been carried out on the 3 main tributaries of the Nairobi River Basin-KWS will also contribute to this database (2) Assemble biological data in the same format as the chemical database and provide reports. NB: In addition UoN will provide data on the reservoirs on the Nairobi River Basin, these will include but not limited to the Nairobi and Jamhuri reservoirs/dams:

- **The World Conservation Union, Eastern Africa Regional Office (IUCN-EARO) Nairobi**

Assist with coordination (2) Provide comparative information/data if required (3) Provide assistance with analysis of available data and description of the river system in the final report.

2.0 Terms of Reference for UoN - Departments of Zoology & Botany

2.1.1. Activity 1.1.1: Survey and analyses of Biological characteristics of the three main tributaries of the Nairobi River, wetlands and reservoirs

2.2 Main Objective

1. To collect, collate and analyse existing biological information in particular regarding the quality and quantity, occurrence, distribution and seasonality of biodiversity of the riverine, wetland and reservoir ecosystems on the three main tributaries. Namely:-
   - Nairobi River tributary,
   - Motoine-Ngong-Nairobi River and
   - Mathare–Nairobi River and catchment up to their confluence and including Dandora Sewage treatment ponds thus
2. To analyse and interpret the biological data to reveal spatial occurrence abundance and distribution along and within the River ecosystems
3. To analyse and interpret and show possible impacts on the biodiversity attributes of the Phase II sub-project's water quality and pollution conditions of the 3 river systems.
4. To produce and disseminate midterm and synthesis reports on the biodiversity data and a comprehensive final report according to the memorandum of understanding signed between the IUCN on 19.09.2005 and UoN on 15.11.2005 respectively

2.3 NRBP Phase III Project Review Study Area

IUCN, UNEP and other stakeholders of NRBP Phase III agreed on the extent of the study area to be as shown in Fig 1 below. This area forms part of the terms of reference for the review and for purposes of the Nairobi River Basin Environmental Management Plan. The area is based on the drainage basin of the Nairobi River its tributaries, the Mathare, Ngong-Motoine Rivers and associated reservoirs and wetlands. This covers most of the Nairobi City and watershed (inside the marked pink boundary). The study area effectively extends from the upper watershed, at the western end of the source rivers on the Ngong-Dagoretti Kikuyu escarpment, to the confluence of the three tributaries – and includes all streams and their sub-catchments.

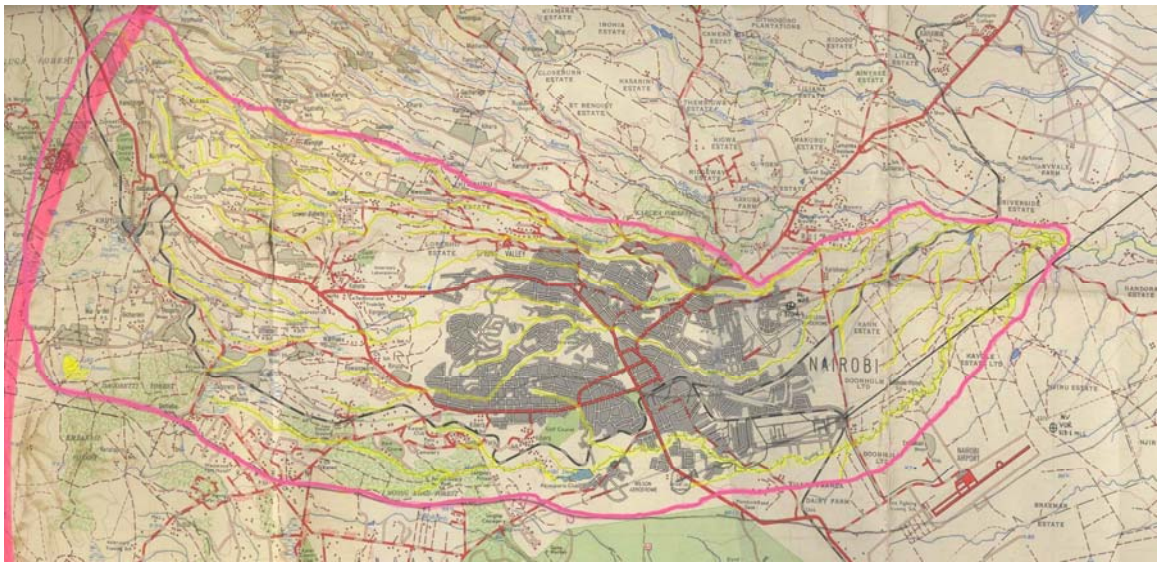

Fig. 1: NRBP Phase III Review Study Area: The basis of selecting this area for the Environmental Management Plan (and so water parameter sampling), is that the entire watershed should be part of the management system as it flows through the city. Activities in the upper (western) watershed will definitely affect the downstream (eastern) area and the central area of Nairobi city. Further for the purpose of this study the area was extended to include the Dandora Sewage treatment area. (IUCN pers.comm. 2005).

3.0 Overview of Previous Nairobi River Basin Initiatives

3.1 The Nairobi River Basin Project

The Nairobi River Basin Project (NRBP) was initiated in 1999 to address pollution problems of the Nairobi Rivers. The NRBP sought ways to reduce the levels of pollution and to promote healthier environment for the people living within the basin. The NRBP was divided into six sub-components including Assessment and Monitoring, public awareness and education, waste recycling and community managed ablution blocks, micro-enterprise development and construction of wetlands.

The studies on assessment, monitoring and analysis of chemical and organic pollution on the various tributaries of Nairobi River and basin conducted in the 1990s showed evidence of high levels of chemical and organic pollution. The studies were based on the 24 sampling points established in NRBP Phase I & II (Fig 2). The major sources of pollution are raw sewage, industrial liquid waste discharges, solid waste, soil erosion and agricultural run-off arising mainly from anthropogenic activities. However the biological components of the aforementioned rivers have not been adequately addressed. This forms the basis of the present NRBP Phase III, which has specifically looked at the existing information on the biological components of the three main tributaries of the Nairobi Rivers and Reservoirs.

3.2 The Phase I of Nairobi River Basin Project (1999-2000)

The Africa Water Network (AWN) implemented the Phase I of the NRBP Pollution Assessment and Monitoring sub-component. This phase focused on the situation assessment of pollution,

involving chemical analysis of water samples collected from Nairobi's three rivers, namely; Nairobi, Mathare and Ngong/Motoine. The pollution assessment survey of the three rivers demonstrated high levels of pollution throughout the river basin. The raw sewage from the informal settlements and discharges from industries are the main polluters of the Nairobi Rivers. Other key sources of pollution were identified as incidences of burst/blocked sewers, direct release of industrial effluent and solid waste discarded into the river.

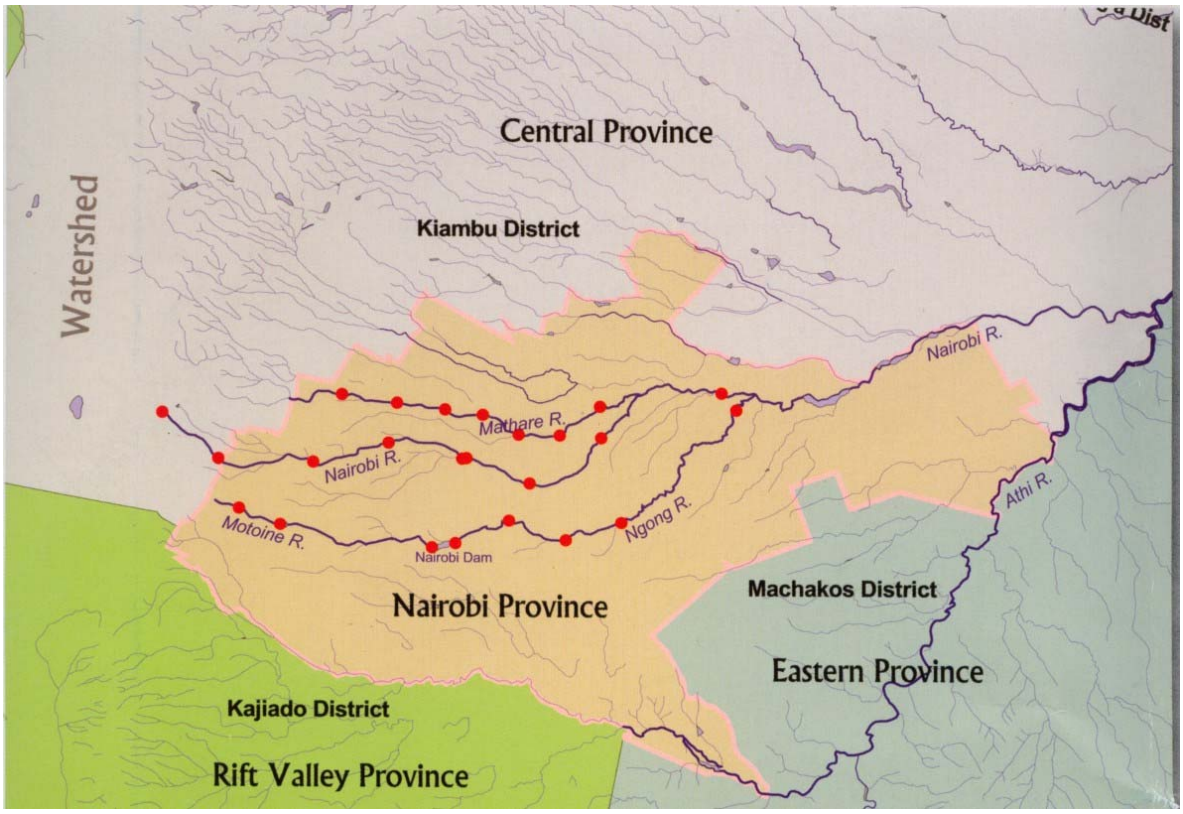

Fig. 2: Map showing Ngong River, Nairobi River and Mathare River which are tributaries of the Nairobi River system showing Sampling stations of the Nairobi River Tributaries in Phase I, 1999 – 2000. (AWN NRBP Phase I, 2000)

3.3 The Phase II of Nairobi River Basin Project (2001-2003)

The Phase II of the NRBP was conducted on the Ngong/Motoine-Nairobi River to provide information and to identify the major point sources of pollution. The NRBP-Phase II monitoring and assessment was conducted on a seasonal basis (Dry and Wet season) and collected useful data and developed a sampling strategy for the other rivers. Baseline data collection for Phase II was conducted by NETWAS in conjunction with the Nairobi City Council.

The Baseline study results for the Phase II from 20 sampling stations, indicated existence of self-purification mechanisms taking place from the first sampling stations, as well as a significant decrease in the pollutants and turbidity as the water passes through several dams. Within the Nairobi dam, pollutants and turbidity decrease due to the retention of water and its slow movement, and a great deal of sedimentation taking place within the dam. Downstream of the Nairobi dam, turbidity increased rapidly and heavy metals concentration also increased downstream of the Nairobi dam. The COD and BOD_5 decreased steadily up to the confluence

with Nairobi River, supporting the claim that some self-purification or dilution or both were taking place but their levels were still high above the limits recommended for natural waters.

These observations were based solely on water analysis as no analysis was conducted on the biota and sediments. It was recommended that full chemical analysis be conducted on the sediments and selected biota to determine whether the elements that appear to have reduced in concentration have actually been removed from the biotic system through uptake or adsorption mechanisms.
After the baseline study, several questions still remained unanswered and it was recommended that additional work be conducted on the rivers to investigate the fate of polluting substances in the general aquatic ecology. It was recommended that sediment be sampled and analysed during the Seasonal Assessment.

The University of Nairobi represented by Centre for International Programmes and Links signed a Memorandum of Understanding with UNEP to continue on the Phase II of the Pollution Monitoring and Assessment in the NRBP. Among other tasks the UoN consortium was to undertake in the project were collect and analyse (laboratory) water and sediment quality samples.

3.4 The Phase III of Nairobi River Basin Project (2005 -2008)

The Nairobi River Basin Programme (NRBP) – Phase III is a four-year programme. Its vision is a restored Riverine eco-system with clean water for the capital city and a healthier environment for the people of Nairobi. The objective of the NRBP is to rehabilitate, restore and manage the Nairobi River ecosystem in order to provide improved livelihoods, especially for the poor, enhanced biodiversity, and a sustainable supply of water for domestic, industrial, recreational and emergency uses. The NRBP-Phase III is a logical follow-up of the Nairobi River Basin Project Phases I and II. These Phases established benchmarks, identified interventions and mobilised the participation of Nairobi residents.

NRBP-Phase III has been designed through a participatory process involving stakeholders drawn from: UN agencies based in Nairobi (UNEP, UNDP and UN-Habitat); five ministries of the Government of Kenya (Water and Irrigation, Lands and Housing, Local Government, Environment and Natural Resources, Roads and Public Works); private sector and civil society. This process identified five result areas whose achievement will contribute to the improved water quality and environment within the Nairobi River Basin.

3.5 Justification for the current review

Biological systems are good indicators of the state of environment. Despite this fact little work has been done on biological analysis of the Nairobi River as compared to chemical analysis. In addition, there is serious lack of documented/published information on extend nature and ecological performance of biodiversity within the basin. There are also gaps in information and methodology used in analysis and thus the need to standardize the monitoring protocols. Despite the extent of pollution, all is not lost as there rich diversity of livings organisms: algae, plants, invertebrates, fish and other wild life in the Nairobi River Basin deserving serious and coordinated assessment and monitoring evaluations.

Several abiotic, anthropogenic and biotic factors influence the composition of riverine ecosystems above and below the surface of the ground. These include the nature of the soil, the geology of the basin, the climate, topography, human cultural and economic activities; and the main biological production and subsistence processes. In particular anthropogenic activities strongly impact the catchment water quality and quantity which inturn negatively impacts on Biodiversity and Ecosystem Health which are strongly interrelated with the natural conditions of the catchment.

4.0 Survey and analysis of Catchment attributes and Biological characteristics

Previous studies and management initiatives in NRBP have recognized the need to document the biological characteristics of the main tributaries of Nairobi River. The main aim of this review was to document the biological characteristics of Nairobi, Mathare and Ngong-Motoine rivers. The report provides the landscape and ecosystem contexts of the three rivers and their biological characteristics. It also provides gaps in knowledge and conservation action and provides a way forward with regard to biological assessment and monitoring.

4.1. Study Area and Methodology

The study area is defined in Fig. 1 above and includes the Nairobi River and its associated tributaries, Mathare and Motoine Tributaries. This drainage basin (inside the pink boundary) extends from the upper watershed, at the western end of the rivers on the Kikuyu escarpment, to the confluence of the three rivers, and includes all tributaries within the basin. The demarcated area includes the Dandora Sewage treatment area and its outfall into the Nairobi River.

The review team comprised of UoN coordinator, one research Scientist, research assistants and technicians from the departments of Zoology and Botany. The information presented here was collected from various sources namely; publications, reports unpublished grey papers, internet sources and theses. It also included field trips/visits for ground trusting to various sections namely: upper catchment, mid and the lower reaches (forests, wetlands, marshes, dams, etc.) of the Nairobi rivers and watershed. Additional photographs were taken during the field trips to show the current status of the habitats as well as any anthropogenic activities or unique features within and around the entire catchment that might be causing some impacts on the biodiversity. Interviews were done on the local communities/people living around and within these acetones. Personal observations made by the research team were also put into consideration and help to enrich the report.

All relevant data was collected, collated, analysed and interpreted at the Department of Zoology, University of Nairobi. This information is presented in form of pictures, graphs and tables, in addition to narrative. The results are presented longitudinally on each tributary ecosystem basis, thus Ngong-Motoine, Nairobi and Mathare tributaries. Similarly, information on biological diversity that is common to all tributaries and their catchments, issues pertaining to urban agriculture, pollution and degradation are presented in this manner. Additional information that is extensive is placed in the appendices; however its quality should be viewed on the same level of importance as the main text. All sources of information are appropriately referenced, except where information is common and in public domain.

4.2 Catchment attributes and characteristics

4.2.1 Landscape level changes

Nairobi lies at an average altitude of 1650m asl (range 1500-1800M). The city lies at the edge of the Athi Kapiti plain and the lower slopes of the Kikuyu and Aberdare escarpment. Land elevation increases from east to west and in fact several streams, including Gatharaini; Mathare, Nairobi, Motoine Ngong and Mbagathi drain the escarpments as they flow eastwards into Athi River (Fig. 1, & Fig. 2, Table 1).

Table 1: Summary of environmental characteristics of the Nairobi River Catchments. NB: Presentation of the Biophysical information on the target tributaries is based on longitudinal descriptions in this table (UoN ASCO 2005)

CATCHMENT	ECOLOGICAL SETTING AND HUMAN ACTIVITY
Upper Forested Catchments	Intensive agriculture and animal husbandry, Sparse Human settlements, Coffee estates, Small urban centres, Vegetable farms along the river banks
Upper Agricultural Reaches	Many well development subsistence agricultural farms and residential plots interconnected with murrum roads and footpaths
Peril-Urban Mid Reaches	Residential areas, Road networks and associated infrastructure, Small holder plots for growing Napier grass, Sugarcane, Kales, Tomatoes, Arrow roots, Bananas, Tree nurseries, Backyard lawns, Garages and vehicle repair sheds, Car wash, Solid waste dump sites, Sewer treatment works
Central Business District	High rise commercial office buildings and other urban developments, Industries, Residential areas, Road networks and associated infrastructure, Small holder plots for growing Napier grass, Sugarcane, Kales, Tomatoes, Arrow roots, Bananas, Tree nurseries, Backyard lawns, Garages and vehicle repair sheds, Car wash, Solid waste dump sites, Sewer treatment works
Lower East lands and Industrial Area	Major Industries and similar enterprises. Urban developments, Industries, Residential areas, Road networks and associated infrastructure
Lower Eastern Peril-urban and Savannah Reaches	Residential areas, urban centres, Slaughter houses, Quarries, Sewer irrigated vegetable farms, Animal husbandry, Sewer treatment works

The physical environment of the city has been considerably altered through a variety of human activities over the years since 1890 when the first Town Village was established. The activities include construction of buildings, roads, bridges, and pavements. Dredging and canalization of flowing water have drastically altered the hydrology of Nairobi. Mining of building stones, especially in the southern and eastern parts of the city and the use of the stones for building in different parts of the city has greatly reduced the natural aesthetic value of the city's landscape.

4.2.2 Ecosystem level changes

Nairobi city and its suburbs enclose an area of 658km^2 of which 117 km^2 comprise forested parks and grasslands. The city lies in the catchments area of River Athi, Athi-Kapiti plains and the forested slopes of the Aberdare Mountain Range. Nairobi City Parks have natural areas of open grassland and deciduous forests at the forest at Karura, arboretum, City Park, Dagoretti and Ngong Forests. The city suburbs of Karen, Langata and Kisser have well-wooded residential plots. Table 1 gives an arbitrary classification of the current status of the NRBP ecosystem.

The city has lost most of its wetlands to human settlements. Formerly extensive wetlands along Nairobi River and Gatharaini River for instance, have been drained to create space for buildings, roads, car parks and recreational facilities. Similarly, wetlands that occurred along the upper parts of Mathare and lower parts of River Motoine have been reclaimed for agriculture, pasture and human settlements.

However, there are a variety of natural wetlands fragments that still persist in the basins of Rivers Mathare, Nairobi and Motoine. The most extensive of those swamps remains occur in, Ondiri Swamp in Kikuyu and Kuna Estate. There are also constructed wetlands such as Nairobi Dam along River Motoine, large sewage treatments works at Dandora, and waste water treatment ponds.

Among the major changes at ecosystem level has been the reduction in natural habitats, especially forests, rank grasslands, and wetlands. Water has also been transferred from Thika river basins into Nairobi so as to meet socio-economic demands for clean water. The waters of Nairobi, Motoine and Mathare Rivers have also been heavily polluted, thereby rendering it unfit not only for domestic, commercial and industrial use but also not suitable to support diverse aquatic life. The rivers currently support limited biological diversity and mainly serve as open sewers to carry away waste from human settlements upstream and the CBD.

4.2.3 Habitat and Community level changes

Because of its unique position between savannah grasslands of southern Kenya and the forested slopes of the Aberdare range, Nairobi R.B. has had an abundance of both grassland and forest communities of both plants and animals. It has also supported transient migratory communities, associated with transitional habitats, such as seasonal wetlands. Among the transitional habitats are riverine reservoirs and seasonal rock pools and marshes in Embakasi, and Kayole west plains and Dandora. These wetlands support substantial numbers of resident and of migratory birds.

5.0 Results of Situation analysis of habitats and Biological characteristcs

5.1 Ngong-Motoine River System

The Ngong/Motoine River System: The Motoine tributary, runs from Dagoretti forest through Jamhuri Park and joins Ngong tributary within Kibera slums. From this point of confluence, the river then becomes Ngong/Motoine, which flows into Nairobi Dam, through Nairobi West suburbs as Ngong River, across Mombasa road and traverses through the Industrial area before joining Nairobi River below Njiru shopping centre. After this confluence the river then becomes Mathare & Nairobi tributaries system commonly called Nairobi River.

5.1.1 Upper section: Head waters and Environs

The main head waters of the Ngong-Motoine river tributary are the Ngong and Dagoretti Forest ecosystems towards the Kikuyu escarpment. According to previous reports (Phase I & II) this section comprises of heavy deciduous forest trees, upper agricultural lands and wetlands. The forests are densely inhabited by natural and agro forest trees composed of *Eucalyptus* plantations, *Croton*, *Cyprus*, *Grevillea*, Bamboo as well as shrubs of *Lantana camara* amongst others. The main human activities include; Intensive agriculture (Coffee plantations), animal husbandry, silviculture, vegetable farms along rivers, charcoal burning and dense human settlements. The forests act as habitats for many species of mammals and birds. Some of the common mammals found within the Ngong and Dagoretti Forests include Duiker, African Hare, Black-faced Vervet Monkey, Bushbuck, Black-and-White Colobus Monkey, Dikdik, Sykes Monkeys, Unstripped Ground Squirrel, Black-tipped Mongoose and White-tailed Mongoose (Nature Kenya, 2004).

Plate 1: **Plate 2**

Plate 1: Watering point for animals at the upper Dagoretti catchment of Ngong River. The small head water springs form rock pools which also provide earth salt for wildlife from the forest. There is high degradation rate of the springs especially in the dry season

Plate 2: Agricultural activities- farmlands at the Upper catchment of Dagoretti/Ngong Forest. Notice the River is reduced to a narrow channel in the middle whilst the wetlands have been cleared for crop production (Plates 1 & 2).

Plate 3a **Plate 3b**

Plate 3a & b: Ngong River and Forest canopy on Ngong Road near Lenana School. These are remnants of indigenous forest found within Markhamia trees. Monkeys, Baboons Mongoose and other mammals are found sparsely within the forest. The Ngong Forest is the source of Ngong River. The water pools are particularly commonest for wildlife during the time of drought (UoN ASCO 2005).

Plate 4a: Dry season: UoN ASCO 2005 **Plate 4b:** Wet season: Phase II UoN ASCO 2003

Plate 4a & b: The various types of vegetation observed along the Ngong River system. Pristine Aquatic vegetation in the upper catchment though with high turbidity during the rainy seasons and little disturbance of the riverbanks that are common in dense populated areas. More robust and healthier Hydrophytes are found here at the source where turbidity was low in the dry seasons

5.1.2 Upper catchment Wetland

There are a variety of natural wetlands that still exist in the Riu swamp near Resurrection Gardens towards Dagoretti town. Ngong-Motoine River system in particular forms the source of Motoine River and is heavily used for agricultural and several domestic uses in the settled Dagoretti area. Most of the wetlands are being lost to human settlements where they have been

drained to create space for farmlands, buildings and other infrastructural facilities. The main plant species found in these wetlands are mainly *Typha* and *Cyperus* sp with Napier grass in the surrounding drainage canals. The plants are usually harvested as fodder for stall-fed animals and as construction materials. The faunal communities include fish such as *Tilapia*, Catfish, *Barbus* and Mudfish and birds like Sacred ibis, Cattle egrets, pied king fisher and African Fish eagle. The main human activities around the wetlands include; subsistence farming of vegetables, sugarcane, floriculture and arrow roots among other food crops. Other activities include quarrying, animal grazing, harvesting of *Typha* and *Papyrus*, bathing and washing of clothes. Drainage of the wetlands for crop farming especially for growing kales, tomatoes, cabbages, and to some extent maize is common on the upper and midcourse parts of Ngong Motoine River systems.

5.1.3. Upper peri-urban, Dams, Reservoirs and Environs

Jamhuri dam & Environs: There are numerous constructed reservoirs found along the Ngong/Motoine River, Jamhuri dam, Motoine dam along Motoine River and Nairobi dam. The Nairobi Dam is heavily covered by water hyacinth, which is as a result of high nutrient loading. *Typha domingensis* and *Cyperus* sp. are dominant around Jamhuri dam and the upper parts of Nairobi dam. Acacia trees around the dams provide nesting sites for weaverbirds. Sport fishing for tilapia occurs in Jamhuri dam where also *Barbus* and *Clarias* are found.

Plate 5a

Plate 5b

Plate 5a &b: Ngong Forest Racecourse Dam (Left**) and Jamhuri Dam** (Right): Sport fishing for Tilapia and *Barbus* is common in these dams. The water in Jamhuri dam is used in the Agricultural Society Kenya showgrounds and irrigation for the show crops and livestock. The spill flood waters are used by some of the Kibera slum residents (UoN ASCO 2005)

Plate 6

Plate 7

Plate: 6. Natural scrub vegetation along Ngong tributary just before its confluence with Motoine. Notice Kibera slums at background

Plate: 7. Animal husbandry: Pigs on the banks of the river at Kibera settlements form a major source of income to the residents

Plate 8

Plate 9

Plate 8: A stream entering Nairobi dam showing massive growth of Typha and Cyperus which dominate the upper parts of Nairobi dam. This stream harbours Catfish and Crayfish (UoN ASCO 2005)

Plate 9: Upper sections of Nairobi dam showing some riparian zones which have been colonized by Typha and Papyrus. In the foreground is Water hyacinth which has completely colonized the dam due to nutrient loading from the Kibera slums in the background (UoN ASCO 2005)

Nairobi Dam and Environs: The Nairobi dam was commissioned in 1953 as a reservoir for water supply for the City of Nairobi. During the initial years the dam also acted as a recreational facility with such activities such as sport fishing, picnics and other related uses. The Nairobi Dam is shallow; it has a surface area of about 356,179 m^2 and a volume of 98,422 m^3.

Plate 10 **Plate 11**

Plate 10: Nairobi dam Southern bank. Water hyacinth grows luxuriantly and acts as foliage for cows. In the background is Nyayo High Rise estate

Plate 11: Animal husbandry within the informal settlement of Kibera/Nairobi Dam: Cows, goats and sheep grazing around the Nairobi dam. Here dairy cows grazing around the Nairobi dam. These animals are kept mainly for milk

The average depth of the dam is 2.76m. The dam inlet is about 1700m while the dam crest is about 1680m above mean sea level. The dam is heavily silted by sediments from erosion and solid waste dumped at various places to reclaim land for agriculture. The water hyacinth has infested the water body disrupting fisheries and recreation (NETWAS 2002).

The presence of Kibera slum on the North eastern bank has resulted in an extension of the *Typha* zone owing to more acidification increased nutrient inputs in runoff from this area. Noticeably are submerged and floating macrophytes with the dominant being *Eichhornia crassipes* (water hyacinth). Hasler (1947) suggested that marked biological changes in shoreline vegetation follow increased nutrient inputs particularly the vegetation found close to the point source. The Motoine-Ngong-Nairobi River is characterized by heavy plant growth on its margins all along that result in upsetting of river ecological balance including the plants being a source of organic pollution upon death and decomposition. (NRBP Phase II 2003).

The water hyacinth in the Nairobi Dam, is a result of continuous discharge of domestic waste and sewage and other plant nutrients in the river. The excessive plant growth in the river also hinders flow of water resulting in stagnant pools of water and reduced light transmittance and hence reduced dissolved oxygen exchange from air to river water (NRBP Phase II, 2003). The water hyacinth has rapidly spread and choked the highly polluted 36-acre Nairobi Dam. The dreaded fresh water weed is used to produce mats and baskets as well as paper (Issaias, 2000). The weed is also be used to produce organic animal feeds, pellets and salts used by dairy farmers "BUT none of these uses controls the weed". There is need to restore the status of the dam and we can achieve this by converting the papyrus reeds and the water hyacinth into usable products.

Up to 1999 the dam was teaming with stocked fish mainly tilapia, *Oreochromis* sp, catfish *Clarias*, Black bass, *Barbus* and *Lebistes*

Zooplankton Community: In between 1989 and 1992 M. Lusweti and K.M. Mavuti started studies on the Limnoecology and zooplankton dynamics on the occurrence and abundance in Nairobi dam before invasion with water Hyacinth (Lusweti (1992) The seasonal composition and abundance in the Reservoir from vertical hauls from different depths at open water station, a littoral station were reported as depended on the nutrient levels, eutrophic status and water flow through rate in the dam.

The community consisted mainly of holoplanktonic Rotifera, Cladocera, Copepoda and the meroplanktonic larvae of Chaoborus (Table 2). Rotifera had a high species diversity comprising of twelve genera including six species of Brachionus: *Brachionus quadridentatus* (500 individuals per litre) *Brachionus angularis* (< 250 individuals per litre) *Brachionus dimidiatus* (< 250 individuals per litre). *Brachionus caudatus* and *Brachionus falcatus* that occurred in low concentrations. *Hexanthra* sp. *Epiphanes macrourus*, *Filinia opeliensis* Ehrenberg, *Asplanchna brightwelli* occurred in large numbers and exhibited blooms during different months of the year, while *Lecane luna*, *Monostyla* sp., *Keratella tropica*, *Elosa woralli*, *Platyias quadricornis*, *Trichocera* species and *Rotaria* sp were rare and occurred only sporadically.

Table 2: Zooplankton taxa in the Nairobi dam: Source (Lusweti, 1992)

CLASS	**SPECIES**
Insecta	*Chaoborus* sp.
Cladocera	*Daphnia pulex*
Cladocera	*Diaphanosoma* sp.
Cladocera	*Ceriodaphnia rigaudi*
Cladocera	*Moina micrura*
Copepoda	*Thermocyclops oblongatus*
Copepoda	*Mesocyclops equitorialis*
Rotifera	*Asplanchna brightwelli*
Rotifera	*Brachionus angularis*
Rotifera	*Brachionus calyciflorus*
Rotifera	*Brachionus caudatus*

The crustacean group included two cyclopoid copepods; *Thermocyclops oblongatus* and *Mesocyclops equitorialis*. The larger Mesosyclops were less abundant and rare during the entire sampling period. Cladocera were represented by four species namely *Ceriodaphnia rigaudi*, *Moina micrura*, *Diaphanosoma excisum*, and *Daphnia culex*. Cladoceran species exhibited seasonal succession with dominant species varying from one sampling session to the next.

The average numbers of total zooplankton was higher during the cool and dry months of June to August (2594 individuals per litre) and relatively lower during the wet months of March to April (662 individuals per litre) due to dilution by rain water and runoff. The abundance of zooplankton for the entire water column at each station over time gave an annual average of 884, 1601 and 1337 individuals per litre for stations 1, 2 and 3 respectively.

The investigation established distinct seasonality in temporal variation of zooplankton abundance in the Nairobi dam. From this study, it was found that Nairobi Dam has zooplankton species composition similar to those found in similar tropical lakes and reservoirs. The findings show trends in seasonal abundance of particular species with composition varying both quantitatively and qualitatively (Figs.3 and 4).

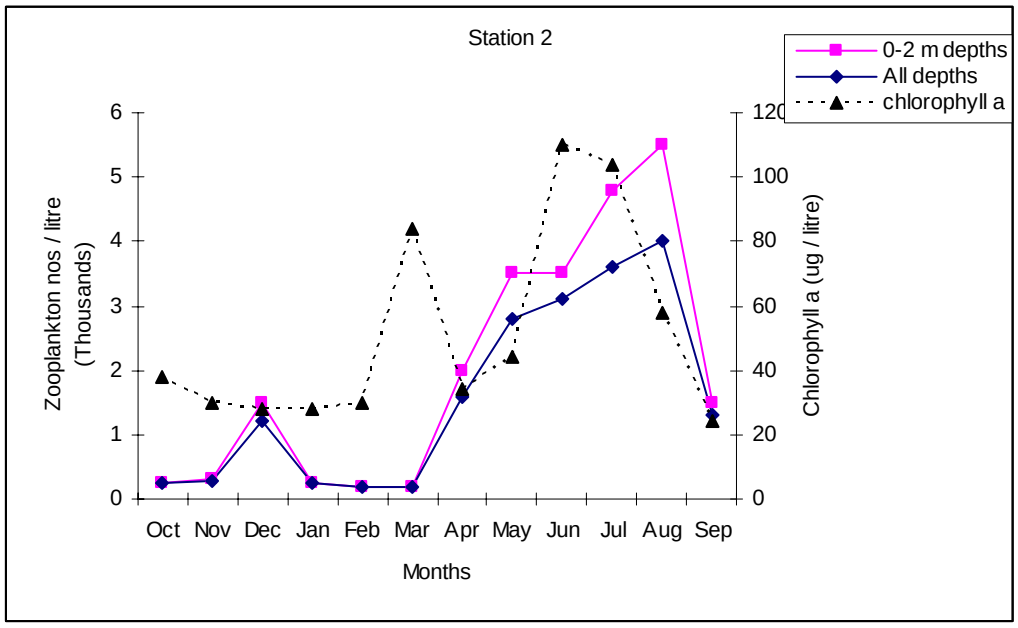

Fig. 3: Spatial variations of zooplankton densities and mean chlorophyll a concentrations in station 2 between October 1989 and September 1990: Source (Lusweti, 1992)

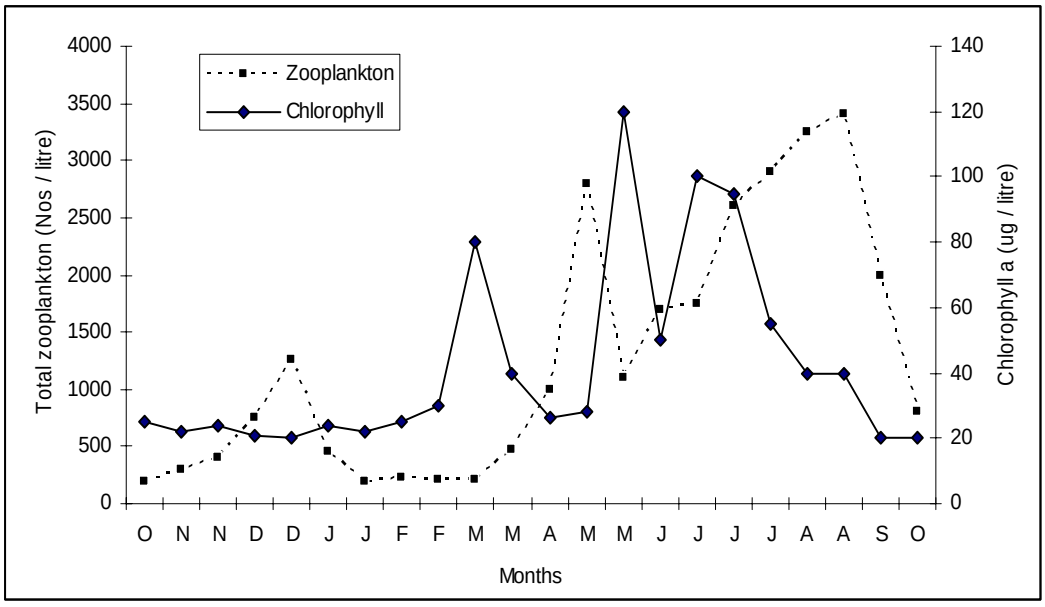

Fig. 4: Temporal variations of mean total zooplankton and mean chlorophyll a concentration in Nairobi Dam between October 1989 and September 1990: Source (Lusweti, 1992)

The presence of only one species of the genus *Daphnia,* a species said to be rare within lowland tropics was also noted. The group composition and succession was influenced by seasonal rainfall and other environmental factors. Zooplankton densities showed a positive correlation with phytoplankton in terms of chlorophyll concentration in the water. Continued monitoring of the zooplankton community was recommended to provide comparative data for studies for example zooplankton species composition as indicators of pollution.

Uhuru park recreation ponds and the CBD (UoN ASCO 2005): Uhuru park recreation ponds are found within the CBD and the drainage channel from the park joins the Ngong-Motoine river system near Mater Hospital. The ponds are overgrown with introduced water lilies. The ponds have been stocked with varieties of Tilapia spp. Substantial numbers of fingerlings and fry were seen foraging amongst the attached lilies. During the rainy season the ponds act as a restocking source to the downstream of the Ngong River below the dam as they escape with flood water.

Pockets of scattered trees along the streets as well as in the adjacent parks of the CBD**.** Depicts the sparse botanical diversity along the City Streets in the Central Business District beside Nyayo House, Kenyatta Avenue, Uhuru Park, Times towers on Haile Selassie Avenue and Central Park around Nyayo monument and NSSF on the Milimani area. Although sparse, the trees are reported to harbour a variety of birds including Marabou stocks along Uhuru Highway town crows, birds of prey and vervet monkeys among others.

Plate 12a **Plate 12b:** *Tilapia zillii* (Family: Cichlidae)

Plate 12a & b: Uhuru park recreation ponds overgrown with water Lillies and stocked with varieties of *Tilapia* sp. Substantial numbers of fingerlings fry and adults were seen densely foraging on the attached lilies. During the rainy season the ponds act as a restocking source to the downstream of the Ngong River below the dam as they escape with flood water. (UoN ASCO 2005)

Plate 13a **Plate 13b**

Plate 13a & b: Pockets of scattered trees along the streets as well as in the adjacent parks of the CBD**.** This depicts the sparse botanical diversity along the City Streets in the Central Business District beside Nyayo House, Kenyatta Avenue, Uhuru Park, Times towers on Haile Selassie Avenue and Central Park around Nyayo monument and NSSF on the Milimani area. Although sparse, the trees are reported to harbour a variety of birds including Marabou storks along Uhuru Highway, African Pied Crows, birds of prey and vervet monkeys among others. (UoN ASCO 2005)

5.1.4 Industrial Area Section of the Ngong River System

This zone is composed of the major industries including Pharmaceutical, Automotive, Fertilizer and Food industries. Residential areas (South B, South C, Embakasi, Umoja and Kayole) and slums are a common feature. Urban farming utilizing sewer waters is common along the river banks growing arrowroots, kales and Napier grass. Riverine vegetation (*Typha, Papyrus,* Grasses and sedges) is common along the riverbanks. The river in this section becomes an open sewer due to direct sewage discharge from most of the industries. It supports limited biological diversity and mainly carries wastes from human settlements and industries. Seasonal wetlands and marshes occur along the rivers, which support transient bird communities associated with transitional habitats such as wetlands and marshes in Embakasi, and Kayole estates. The wetlands support thousands of migratory birds. Flash floods support riverine vegetation which acts as habitats for frogs, Toads and insects. This situation persists upto the confluence with the Nairobi River system and beyond below the Dandora sewage outfall. Occasionally, however some tolerant aquatic macrobenthic invertebrates are found in the backwater sediment where there are substantial amounts of dissolved oxygen. Some of these are listed in fig. 11 (NRBP Phase II Report 2003).

Plate 14 **Plate 15**

Plate 14: Ngong River as it enters the industrial area. Direct industrial effluent discharge is common as evidenced by the blue colour in the background. Most benthic organism cannot survive in the bottom due to poison of dyes and detergents. However during the rainy season this area has been reported to have substantial amounts of tilapia and barbus fish communities (NRBP Phase II 2003)

Plate 15: Ngong River as it traverses the industrial area. Various types of vegetation are observed along River system. Napier grass is also planted along the river banks and is used as fodder (NRBP Phase II 2003)

5.1.5 Benthos of the Ngong River

Several groups of benthic worms, insect larvae and snails were encountered in the river bottom sediments along the Ngong-Nairobi River during the NRBP organisms (benthos) Phase II. Most lie in the category of pollution tolerant benthos (Table 3). These were represented by midge flies (*Chironomus* sp), Oligochaete worms (*Tubifex* sp), Leeches (Hirudinea) and pouch snails (Mollusc; *Lymnea* sp) (Appendix 1). Chironomids, Oligochaetes and Hirudinea have been found to be indicators of poorer water quality in flowing waters, and are classified as pollution tolerant benthos (macroinvertebrates). Oxygen levels, toxic chemicals, nutrients and habitat quality affect availability of benthos in any aquatic ecosystem. This array of factors makes it hard to make the decision of whether an organism is an indicator of better or poor ecosystem quality. Thus a bioindicator of poor water quality in a flowing water ecosystem can be an indicator of better conditions in wetlands.

Table 3: Benthic communities encountered during sampling along Ngong/Motoine-Nairobi River. Source: (NRBP Phase II 2003).

Sampling station & Name	Season	Community	Common Name	Nos./Ft^2
3B	Dry	Oligochaetes	Sludge worms	**4**
6B	Dry	Oligochaetes	Sludge worms	**3**
11B	Dry	Chironomids	Lake flies	**600**
14B	Dry	Oligochaetes	Sludge worms	**14**
		Hirudinea	Leeches	**2**
16B	Dry	Oligochaetes	Sludge worms	**4**
17B	Dry	Oligochaetes	Sludge worms	**3**
11C	Dry	Chironomids		**160**
		Oligochaetes	Sludge worms	**3**
14C	Dry	Oligochaetes	Sludge worms	**70**
16C	Dry	Oligochaetes	Sludge worms	**5**
3E	Wet	Not accessible		
6E	Wet	Oligochaetes	Sludge worms	**4**
11E	Wet	Oligochaetes	Sludge worms	**12**
		Hirudinea	Leeches	**1**
		Chironomids	Lake flies	**3**
14E	Wet	None		
16E	Wet	Oligochaetes	Sludge worms	**2**
17E	Wet	Not accessible		

NB: Station 3: Upstream – Relatively less polluted section
Stations: 5 to 14: Midstream – High organically polluted from sewage detergent
Stations 15 to 17: Downstream – Extremely highly polluted with industrial and organic sewage effluents

5.2 Nairobi River Tributary Habitats & Biota

5.2.1 Upper section: Head waters and environs

This section comprises of forested lands, upper agricultural lands and wetlands of the Kikuyu Forest and Wetlands in the Upper Catchment. The main sources of the Nairobi river tributary is the Ondiri/Kikuyu swamps and springs on the Kikuyu escarpment (Plates 16, 17 & 18). The forested catchments adjacent to the swamps are densely inhabited by natural and agroforest trees composed of *Eucalyptus* plantations, *Croton, Cyprus, Grevillea*, Bamboo and shrubs amongst others. The main human activities include intensive agriculture, Animal husbandry, Silviculture, Vegetable farms along rivers, Charcoal burning and dense human settlements. The forests adjacent are habitats for a few species of mammals, and birds, especially Monkeys and Baboons.

The only natural wetlands that still exist in the Nairobi River's basin is the Ondiri swamp in the upper Kikuyu catchment which is the source of the Nairobi River. However, its immediate catchment is heavily used for agriculture and several domestic residential uses (Plate 20). The

wetlands is being lost to human settlements as it has been drained to create farmlands, buildings and other infrastructural facilities.

The main plant species found in the wetland are mainly *Typha* and *Cyperus* sp with planted Napier grass in the surrounding. These plants are harvested as fodder for animals and as construction materials.

The faunal communities include fish such as *Tilapia*, catfish, *Barbus* and mudfish and birds like sacred ibis, cattle egrets, pied kingfisher and african fish eagle. The main human activities along the valley wetlands below include; subsistence farming of vegetables, sugarcane, floriculture and arrow roots among other food crops. Other activities include quarrying, animal grazing, harvesting of *Typha* and *Papyrus*, bathing and washing of cars.

Plate 16a **Plate 16b**

Plate 16a & b: Upper most spring Reservoir just above the Ondiri swamp with luxuriant hydrophytes. It is the source of Nairobi River used for domestic and agricultural (irrigation) activities. Notice the pipe for pumping water. The depth of this spring is more than 20 metres. Local tales have it that it is linked underground to Lake Naivasha (UoN ASCO 2005).

The Kikuyu springs and Ondiri swamp pools are habited by Water lilies *Nymphaea caerulea*. Water lilies are considered a well-established indicator of clear oligotrophic waters (Dumont 1981). This section of the river was the most diverse with 16 macrophytes species being collected. Downstream the decrease in the number of species is related to an uniformization and spatial reduction of the habitat designated to riverine vegetation. Hydrophytes were ubiquitous and largely dominated by *Cyperus immensus*, *Pennisetum purpurem* and *Amaranthus hybridus* (UoN ASCO 1998).

Plate 17a

Plate 17b

Plate 17a & b: Ondiri Swamp its outflow and surrounding environs showing human encroachment around the wetland, in far ground catchment are new flower farms and Napier grass in the foreground. Notice the grass-reed swamp which is entirely one large spring producing gallons of water for the City of Nairobi as well as feeding the Nairobi River tributary. (UoN ASCO 2005). The reeds are dominated by *Cyperus spp*.

Plate 18

Plate 19

Plate 18: Ondiri Swamp - the source of Nairobi River. This is a habitat for several fauna and flora, Crowned Crane. The Cyperus swamp are preferred foraging and breeding habitat for many birds especially crested cranes as seen in the foreground and breeding swipe (UoN ASCO 2005).

Plate 19: African Snipe found in the Ondiri swamp. This swamp is rich in Bird communities as part of biodiversity in the wetland ecosystem (UoN ASCO 2005).

Plate 20a **Plate 20b**

Plate 20a & b: Kikuyu Forest left bank and agricultural farmlands along the Nairobi tributary outflow just from the Ondiri Swamp on the Upper catchment. Notice that the forest is a mixture of indigenous and exotic trees intactly conserved. The cleared right bank is planted with a mixture of vegetables and soil erosion is the order of the day during the rainy season (UoN ASCO 2005).

5.2.2 The riverine and wetland vegetation and shrubs

All along the river banks are overgrown with herbaceous plants and sometimes covered by short grasses and fringing reeds in the lower reaches. Upstream in closed reaches form quite dense overhang, forming canopies as shown in some of the riparian trees which are exotic while others are indigenous. Tree canopies form a source of terrestrial invertebrates falling into streams. The dominant forest trees around the catchment area of the reservoir are dry semi-deciduous type (Trump 1967). The dominant species are *Croton megalocarpus*, *Brachylaena huillensis*, *Calodedrum capense*, *Teclea* spp. *Strychnos henningsii* and *Diospyros abyssinica.* The area immediately surrounding the reservoir is semi-arid with sparse vegetation of grasses, including *Themeda triandra*, *Eragrostris pycnostachys*, *Panicum maximum*, *Setaria plicatilis*t and *Sporobolus* sp. scattered bushes and stunted trees included *Barleria micrantha*, *Vernonia holstii* and *Acacia* sp. particularly on the western side. The Ondiri Swamp had a catchment of 2 km in length and grasses and sedges, *Cyperus laevigatus* L., dominate the vegetation, *Cyperus maculatus*, *Leersia hexandra* (Njuguna, 1978). All along the riverbank's mainly, are well characterised by the presence of truly hydrophytic vegetation such as *Veronica anagallis-aquatica* and *Rorippa nasturtium-aquaticum*. In addition a variety of species strictly related to aquatic habitats as *Leersia hexandra*, *Polygonum salicifolium*, *Ranunculus multifidus* and five species of *Cyperus (*Mathenge pers. *Comm*.). Aquatic vegetation is affected by water pollution and disturbance of the riverbanks that are common in dense populated areas. More robust and healthier Hydrophytes are found at the source where turbidity was low.

5.2.3 Upper Catchment and Upper peri-urban agricultural lands

Includes the peripheral residential areas like Kawangware, Kangemi, Muthangari, Lavington, Kileleshwa, Arboretum, Westlands and others. Remnants of indigenous forests occur like Arboretum, as well as wooded plots, within residential areas. Remnants of natural wetlands

occur in Kawangware and Lavington areas. *Typha domingensis* and *Cyperus* sp. are dominant around Kawangware and Lavington swamps. Acacia trees along the river provide nesting sites for weaverbirds.

The upper catchments are also intensively farmed for Coffee estates, Sugar cane, Napier grass, Arrowroots, Kales, Maize, Beans, Bananas, Cabbages. Residential areas, animal husbandry and quarrying are also common human activities all along this section. Animal husbandry and crop farming occurs along the river banks, and mainly involves Napier grass for zero grazing, Kales, Arrow roots, Sugarcane, Bananas, tree nurseries among others. Solid waste dumpsites, slaughter houses, Water treatment works also characterize the upper peri-urban area. The Lavington swamps and wetlands have been reclaimed for residential houses with only a small section remaining.

Plate 21a

Plate 21b

Plate 21a: Remnants of the once flourishing Lavington Wetland, which has now been reclaimed for real estate development and urban agriculture. Many houses in Lavington area are built in wetlands with *Typha* reeds along the perimeter wall of the house. Most of the houses in this former Lavington wetland have been constructed on sinking sand (UoN ASCO, 2005)

Plate 21b: Diversion of the normal water flow in the now reclaimed Lavington wetland to create space for real estate development. The Braeburn School is seen in the background (UoN ASCO, 2005)

5.2.4 Lower Upper Catchment agricultural lands

There are pockets of E*ucalyptus* sp., within Lavington area, Chiromo and Riverside areas. Along Kirichwa River passing through Chiromo are plots of Arrowroots, Bananas, Kales and tree nurseries. Within Lavington, Riverside and Arboretum areas, the river valley has been reduced to a very narrow valley due to land grabbing by real estate developers. Bamboo (*Bambusa vulgaris*) dominates the riverine vegetation along Kirichwa River in Chiromo. This plant was imported from India as an ornamental plant but has colonized some sections of the rivers (Mathenge pers. Comm. 2005, UoN Team 2005). Plate 22-24 show some wetlands vegetation cover, agricultural crops and agroforest trees on the lower Upper Nairobi River tributary.

Plate 22 **Plate 23**

Plate 22: Riverine vegetation mainly Bamboo forest along Nairobi Kirichwa tributary, beside Chiromo Campus, from the Lavington swamps. The bamboo protects the banks from degradation (UoN ASCO, 2005).

Plate 23: After the confluence of Kirichwa kubwa and Kirichwa ndogo around Museum hill. Bathing and washing clothes by street families is evident. Top right is the Museum of Kenya agroforest which contains some species of indigenous sources (UoN ASCO, 2005).

Similar to the Motoine River, the upper catchment of Nairobi River is intensively farmed. Most are smallholder plots with subsistence farming mainly, sugar cane, Napier grass, Arrowroots, Kales, Maize, Beans, bananas, Cabbages. Residential areas, animal husbandry and quarrying are also common human activities in these areas. Interspersed with the crops are agroforest and fruit trees which provide good cover for the soils.

5.2.5 Central Business District

Below the Museum bridge the Nairobi River traverses through the Museum wetlands in Ngara and through and draining the CBD (Plate 24). The CBD is composed of High rise commercial offices, Industries, Road networks, Urban developments, Urban agriculture along river banks (irrigated by sewer water), Solid waste dump site, Sewer lines, Railway yard, Automotive garages, Car washes, Residential areas and slum areas. Flash floods and open sewers support the growth of *Typha, Cyperus papyrus,* Grasses and sedges along the river banks. Tree nurseries are also common along the rivers or in areas with open sewer lines. The vegetation supports diverse aquatic life like frogs, toads, dragonflies among other fauna. The commonest trees are; eucalyptus, palm, jacaranda and pride of Bolivia, which is the commonest tree, planted along the streets of Nairobi. The Museum hill section is a confluence of the two Kirichwa tributaries to form the Nairobi river. This section is a famous bathing area for street families (see Plate 23). Near and below the Globe round- about and Ngara section are motor vehicle garages specializing in spray painting and car washing and solid waste dumping sites. From this section the Nairobi River starts being an open sewer due to direct sewage discharge into the river system (Plate 25). The commonest riverine vegetation is a mixture of grasses and sedges with Napier grass.

The CBD has lost most of its wetlands for commercial buildings and other infrastructure. However numerous seasonal wetlands occur during the rainy season.

Plate 24 **Plate 25**

Plate 24: Behind Kijabe Street the Nairobi River is a common solid waste dumping site on the river banks. Along side the Banks are covered with Napier grass and water plants (Hydrophytes (UoN ASCO, 2005).

Plate 25: Globe round-about section. Here the river starts receiving pollutants from human activities (Garages, makeshift hotels, car washing bays and solid waste dump sites) established along the river banks (UoN ASCO, 2005).

5.2.6 Conservation initiatives of native *Sesbania* spp. Germplasm from the Nairobi River Catchment (Abridged and adopted from Ndungu *et al.*, 1994)

The Nairobi area has a unique habitat, dissected by numerous rivers and streams which ultimately flow into the Athi River. It has a great diversity of local ecological conditions of altitude, rainfall and soil types within a relatively small area. In recent times the habitat in Nairobi has changed dramatically with increased urban pressure.

The natural vegetation in the NRB area has been greatly modified since 1899 when a base railway camp was set up in the then mosaic of open grassland, montane closed forest and moist woodland swampy areas. In many areas of NRB it is now difficult to determine by visual analysis, what the native vegetation was like originally. The city streets are tree-lined, and gardens planted mainly with introduced exotic ornamental trees and shrubs. However, small and progressively shrinking pockets of indigenous vegetation still remain undisturbed in parts of Mathare-Karura, the Aboretum, the City Park, Dagoretti and the Ngong Forests, *inter alia.* They include woodland, forest and grassland species.

Sesbanias in the city are usually found along streams in the woodland and grassland areas. They are usually not found in closed forest areas but can occur occasionally away from streams in woodlands and forests within the city. Because sesbanias are pioneer species they are also found growing in disturbed areas around the city e.g. new building and demolition sites. S. *sesban* var. *nubica* is endemic to the city area. Although, in theory, seed could have been brought into the city in soil and other building materials (river sand for concrete).

Ex situ conservation affords an excellent opportunity to consider pertinent germplasm collection issues such as (a) the need for systematic inclusion of urban areas in exploration strategies, and (b) development of strategies for the maintenance of active, base and core *ex situ* germplasm collections of *Sesbania spp.*

Ndungu *et al* made collections of two endemic perennial sesbania taxa viz. S. *sesban* var. *nubica* and its close relative, S. *keniensis*, found within the city of Nairobi. Populations of both species are under threat from urban expansion.

The Rationale for the collections and Conservation of native flora: Sesbanias are nitrogen-fixing legumes and are used in sub-Saharan Africa for soil improvement purposes, stakes, fodder and fuel wood. *Sesbania sesban* has shown particular promise for improved fallows where its soil improvement potential in local farming systems is widely recognized. Most sesbania species are small plants of 1–2 years longevity although a few, such as S. *sesban*, are woody perennials.

The riverine areas typically inhabited by sesbanias are endangered by urban development, and peri-urban agriculture, horticulture and dairy farming. The river systems around the city have been altered in recent times, and many have diminished stream flow or have had their courses diverted, or have even gone underground for part of their course (eg Motoine River at Dagoretti): some seasonal streams have disappeared all together. In Nairobi, it is common for declared green belt areas (even stream banks) to be suddenly resumed for development. For all these reasons a strong case exists for *ex situ* conservation (rather than *in situ*) of the wild native sesbania populations around and within Nairobi, as part of an overall strategy for the conservation of genetic resources of *Sesbania* species.

The principal species (holotype) of S. *keniensis* was collected by Rayner in 1949 from a population now enclosed within the city (collection no. 210). The holotype is lodged in Kew, U.K. and the isotype in the East Africa Museum, Nairobi. The exact location recorded is “the French mission, Nairobi, below Loreto Convent on the banks of the Nairobi river”. The French Mission is now referred to as St. Mary's School. Only a few trees now remain at this location.

General interest in S. *keniensis* results from its apparent close taxonomic affinity with the commonly used S. *sesban*. The two species resemble each other but are usually separable using three key features viz. S. *keniensis* has fewer flowers per inflorescence (2–3), has longer staminal tubes (18–23mm long) and has an almost glabrous appearance. In his original description of the species Gillett (1963) notes: “S. *keniensis* has in the past been much confused with S. *sesban* which grows alongside it”. However, Gillett believed that S. *keniensis* was more closely related to S. *goetzii*, which is one of three perennial native *Sesbania* species in Africa, (S. *keniensis* and S. *Sesban* being the other two).

The collections and sampling strategy adopted was based on river systems. Somewhat surprisingly, each minor stream usually had only either one of the two species present along the lengths of the streams searched. Each population was usually small and consisted of 5–20 individuals. S. *sesban* was also found on ridges away from the streams but S. *keniensis* never so. S. *sesban* was common on several disturbed non-river sites around the city.

S. *keniensis* is now endangered at the site of the holotype. A special collection at this site was made around Loreto Convent Msongari and St. Mary's Boys School. Only ten individuals were found along the Nairobi river up to 1 km downstream. About 0.5 km upstream from St Mary's we found a small stand of nine trees of the two species targeted for collection in mixture around

a small swampy area. No obvious hybrids were observed although controlled crosses of the species have been successfully made (Heering and Hanson 1993).

The Nairobi collections yielded eight seedlots (accessions) of the two taxa, *Sesbania sesban* var. *nubica* and *Sesbania keniensis*. The details of the collections are summarized in Table 4 with latitudes and longitudes determined by a global positioning system (GPS) receiver.

Most stands of sesbania found in the city were small. Single tree collections were made, the possibility of later bulking seed on a per urban catchment basis being left open. All seed was divided and stored in either base or active collections. Base collections are stored (at -20°C) at the National Genebank of Kenya, and active collections are stored (at 5°C) at the Kenya Tree Seed Centre (KEFRI). Careful documentation of all the seedlots was done using the standard germplasm collection form of the Multipurpose Tree Germplasm Resource Unit of ICRAF.

Table 4: Collection details for Sesbania in the urban environment of Nairobi

Species	Site	Long. (°E)	Lat. (°S)	Alt. (m)	Nbr. of parent trees
Sesbania sesban var. *nubica*	Brookside Drive	36°47.740'	01°15.395'	1740	6
	James Gichuru Road	36°46.339'	01°16.669'	1720	5
	Loreto Convent	36°46.569'	01°16.066'	1740	1
	Muthangari Police Station	36°46.404'	01°15.969'	1740	1
	St. Mary's Boys School	36°46.720'	01°16.068'	1720	1
Sesbania keniensis	Loreto Convent	36°46.569'	01°16.066'	1740	4 (8)[1]
	Muthangari Police Station	36°46.404'	01°15.969'	1740	2 (6)[1]
	St. Mary's Boys School	36°46.664'	01°16.091'	1720	1 (3)[1]

[1] Figures in brackets represent number of *Sesbania keniensis* trees extant at each location.

Discussion and Conclusions.

Sesbanias seem to be of little use to city residents although S. *sesban* is widely used on farms in Western Kenya and many city residents from the country are familiar with the species. In the city sesbanias are cleared to make room for food and fodder crops, and for building and road construction. The use of sesbanias for firewood and in soil improvement, was not noted anywhere in the city.

The ICRAF Multipurpose Tree Germplasm Resource Unit (MPT-GR) maintain core collections of S. *sesban* var. *nubica* and S. *keniensis*. The importance of inclusion of genetic material from these in the core collection in the Tree Germplasm Resource Unit will provide an exact comparative base by which subsequent evolution and variation within the species can be measured.

The movement of plant germplasm worldwide, often carried out in uncontrolled ways and without adequate documentation, and its introduction into new habitats (like areas in and around Nairobi), is a major threat to local genepools, and raises the need for collecting germplasm of native species in rapidly developing urban areas. In the present case, it is possible that native *Sesbania* species may have hybridized with introduced sesbanias, with a loss of their genetic integrity. A serious concern in the present situation was that significant amounts of inbreeding and genetic drift may have occurred through depletion of the original *Sesbania* stands, resulting in serious genetic erosion.

It is clear that populations of the two native sesbanias viz. S. *sesban* var. *nubica* and S. *keniensis*, in the Nairobi city area are endangered, although losses of such populations are not considered to endanger the species as a whole. Loss of the type population of S. *keniensis* is more serious in that it will restrict the efficacy of future research into the exact taxonomic identity of the species and its relationship with its close relatives viz. S. *sesban* and S. *goetzii*. Under these circumstances *ex situ* conservation collections are justified for both S. *keniensis* and S. *sesban*. Collections of both species from the type area will provide a good germplasm source for future taxonomic studies and possible use.

5.2.7 Phytoplankton Community Nairobi River system

According to studies by Njuguna (1978), diatoms and the blue green algae dominate the phytoplankton in the Nairobi Rivers. They include the filamentous and coccoid cyanophytes; L*yngbya conorta*, *Anabaenopsis tanganyikae*, *Oscillatiria* spp., *Microcystis* spp., *Microcystis aeruginosa*, and baccillariophyta e.g. *Melosira* sp. Chlorophytes include the *Pediastrum duplex*, *Closterium* sp., *Ankistrodesmus* sp., and *Cosmarium* sp. Algal blooms as a result of increased primary production were observed along some sections of the river channel. *Microcystis* is an indicator of high levels of organic pollution in freshwater bodies.

Differences in the composition, distribution and abundance of the phytoplankton assemblages in the upper, mid and lower reaches are related to factors such as river discharge, nutrient levels and flushing rates in the main tributaries.

5.2.8 Assessment of water quality using micro flora in Nairobi River system

Environmental variables and diatom data were collected by (Ndiritu *et al*., 2003) from Nairobi River, Kenya, in order to study response to water pollution by micro flora (diatom) assemblages attached to natural and artificial substrates. Fifteen stations were sampled, covering a distance of 60 km from the source of Nairobi River. Multivariate analysis of the results revealed three types of environmental gradients in the river. The first gradient represented the upper stream stations, whose water samples had high oxygen levels. The second gradient was represented by mid stream stations whose water was characterised by high agricultural pollution and high nitrate concentrations. Lower stream stations whose water corresponded to both industrial and domestic waste with all stations having high measurements of total dissolved solids represented the third gradient, total suspended solids and orthophosphates. Species richness, diversity and evenness of diatoms tended to be higher in the second group while high densities were recorded in the third group. The results further showed that the composition and distribution of diatom assemblages significantly varied with water quality and substrate.

5.2.9 Distribution of Macroinvertebrates along the Nairobi River tributary

The composition and distribution of macroinvertebrates, along Nairobi river tributaries was studied by Pacini in 1989. Five taxonomic groups have been described in detail: Caenis, Simulium, Chironomidae, Cheumatopsyche and Baetidae. The headwaters were characterised by the presence of aquatic macrophytes and low in suspended silt. These probably did not represent direct food resource for aquatic invertebrates because of their high C/N value and low digestibility (Njuguna, 1978). However, it is known that some macrophytes like *Roripa* are efficient in trapping Particulate Organic Matter (POM) and provide attachment substrate for periphyton and a number of aquatic invertebrates (Cummins, 1979). At the source, the invertebrate community was dominated by Simulidae (53%) and some Chironomids. Predators were also present with the Triclads (19 %) (*Dugesia tigrina*) a few Gyrinidae larvae (*Aulonogyrus, Dineutus* and *Orectogyrus*). The presence of Gyrinidae at the headwaters and their disappearance downstream was probably related to the reduced transparency of the water. In the upstream the density was low with an average of 80 ind. / m^2.

At the source, collectors mainly Simulidae and Chironomids dominated the invertebrate community. Downstream, silt and particulate organic matter accumulated. This led to an increase in the proportion of collectors with the appearance of large numbers of Baetidae, and *Cheumatopsyche* spp. The average density of the macroinvertebrates was 313 individuals per m^2. The distribution of the invertebrate fauna along the Nairobi Rivers is characterized by continuous replacement in taxonomic composition and a general decrease in the number of individuals with few species being the dominant from season to season (Pacini 1989). Figs. 5 to 9 give a graphical summary of the benthic macroinvertebrates along the Nairobi River tributary adopted from Pacini (1989).

<u>Caenis:</u> Mayflies

This group of invertebrates is ecologically diverse and is commonly found in pristine habitats with high temperatures and lower dissolved oxygen levels. They occurred in low densities; 20 ind. / 0.2 m^2. Its distribution was related to the type of habitat. *Caenis* are sediment or deposit feeders hence their presence was related to coarse particulate debris and decaying vegetation. Higher numbers were recorded in the upper stream and current speeds did not affect the numbers. In stations downstream of reservoirs along the river, *Caenis* numbers were relatively low due to the trapping of silt hence reducing the habitats for *Caenis*.

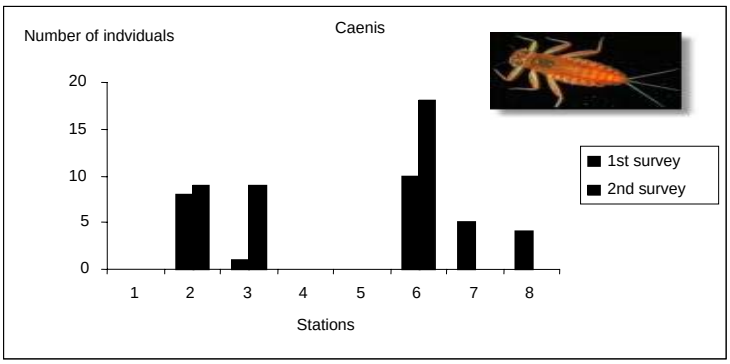

Fig. 5: Longitudinal distribution of *Caenis*: Source: Pacini (1989). **NB:** Stations 1 to 4 – Upstream of the museum bridge Stations 5 to 8 – Midstream below the Museum Bridge

Simulium

The larvae of the Blackflies *Simulium* sp., in the Order Diptera are typical filter feeders hence they rely on water currents to provide them with fine particulate debris. They specifically occurred in areas where current speeds are above 32 cm/s. *Simulium* are epibenthic on hard substrates hence are only found in areas having rigid attachment substrate. Abundance of S*imulium* is related to several factors like;

- High current speeds (above 32 cm/s),
- Presence of reservoir upstream which provides planktonic material and traps sand and silt which may have an abrasive effect on these organisms
- Stability of the riverbed surface providing an increased effective area for larval colonization.

Shallowness of the water, which enables effective filtering of suspended particulate matter, Phytoplankton and Bacterioplankton. This group of invertebrates is an indicator of cool and well-oxygenated waters.

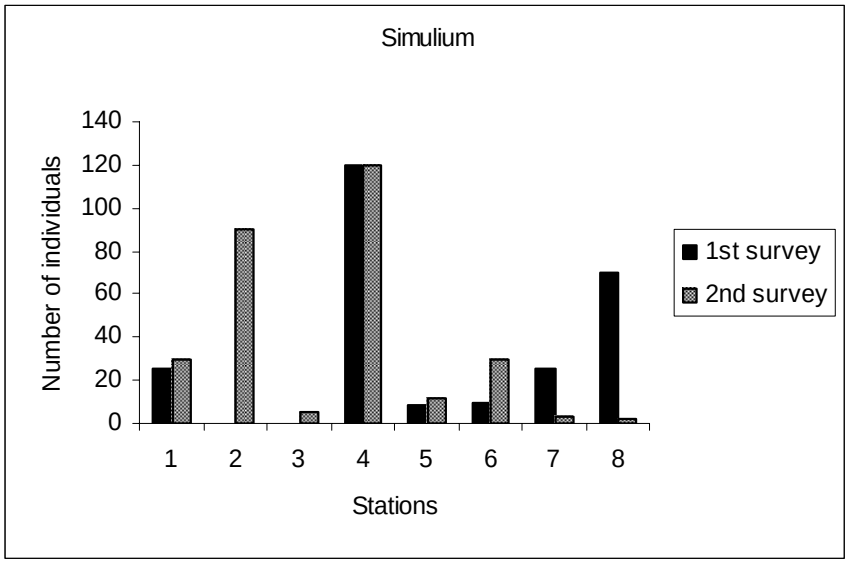

Fig. 6: Longitudinal distribution of larval Simulium. **NB:** Stations 1 to 4 – Upstream of the museum bridge Stations 5 to 8 – Midstream below the Museum Bridge

<u>Chironomidae</u>: Midge flies

The larval stages of the family are widely distributed along the Nairobi River Fig.7. The commonest forms found were the 'little green forms' (common found in sub-family Orthocladiinae) and the large reddish C*hironominae*

'Plumosus' (Chironominae) mainly in polluted reaches. Many chironomidae are filter feeders, other groups are collectors and grazers. Chironomids are able to live in areas of limited oxygen levels and high organic pollution and hence are useful as biological indicators of water quality in riverine ecosystems. They are indeed found all along the polluted sections of the three river tributaries and in Nairobi below the Museum Bridge to the Dandora outfall.

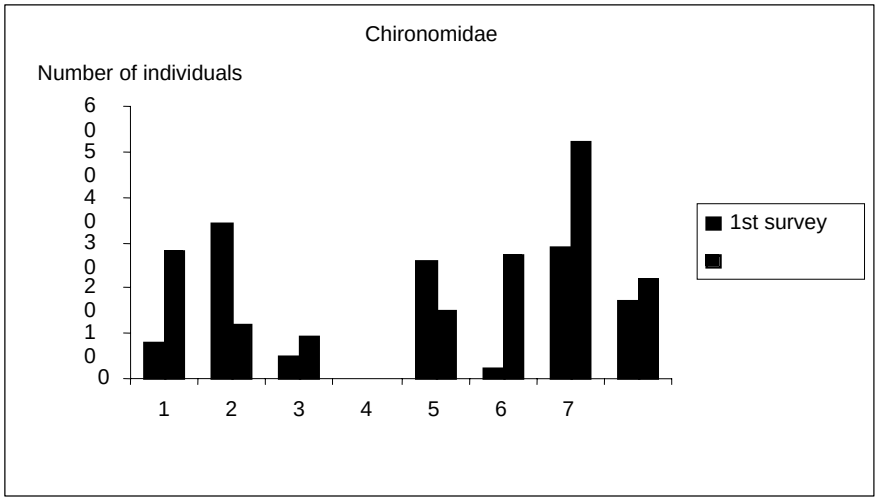

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Fig. 7: Longitudinal distribution of Chironomidae : Source Pacini (1989) **NB:** Stations 1 to 4 – Upstream of the museum bridge Stations 5 to 8 – Midstream below the Museum Bridge

Cheumatopsyche

The net-spinning trichopterans Chematopsyche (caddisflies) are classified as filter feeders and their diet varies with seasons. The larvae of two types of species were identified i.e *Cheumatopsyche* sp. A (tolerant species) and *Cheumatopsyche* sp. B (intolerant species). The high occurrence of *Cheumatopsyche* in Nairobi river can be related to the same factors cited in the case of *Simulium.* These two groups showed similar longitudinal distribution along the River (Fig. d). The tolerant species had a wide distribution and appeared at the Nairobi Falls below Dandora among the first species recovering from the silt pollution. The less tolerant species were exclusively observed at the sources of the river. This distribution was attributed to the size and abundance of particulate matter and the amount of suspended silt carried by the water. The presence or absence of the less tolerant species is an indicator of high quality waters whereas the tolerant species are an indicator of poor water quality in which the less tolerant are absent.

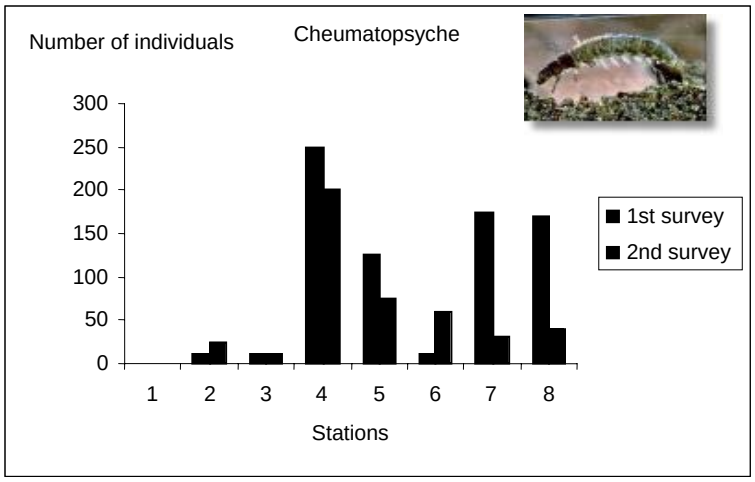


Fig. 8: Longitudinal distribution of Cheumatopsyche : Source Pacini (1989) **NB:** Stations 1 to 4 – Upstream of the museum bridge Stations 5 to 8 – Midstream below the Museum Bridge

<u>Baetidae</u>: Mayflies

Two genera, *Baetis* and *Centroptilum (Baetidae)* were identified along the Nairobi Rivers. Fig. 9 shows their distribution along the river. The family showed a longitudinal distribution related to availability of attachment substrate, food source and amount of suspended silt. Numbers increased from the river source downstream. Naturally baetids tend to live in unpolluted waters with densities of upto 10,000 ind/m^2. Species of *Baetis* are the most less tolerant to pollution and therefore the absence is good indicators of water quality ecosystem.

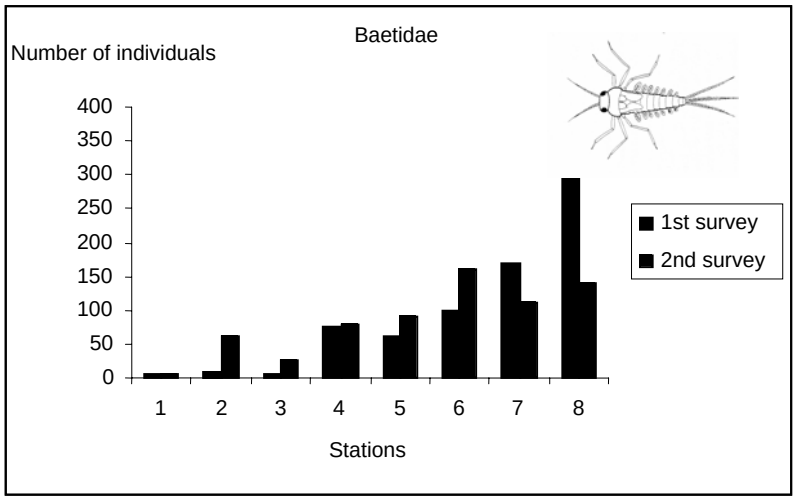


Fig. 9: Longitudinal distribution of Baetidae: Source Pacini (1989). **NB:** Stations 1 to 4 – Upstream of the museum bridge Stations 5 to 8 – Midstream below the Museum Bridge

Overall the most diverse orders of benthic macroinvertebrates along the Nairobi River tributary were fly larvae (Diptera), May flies (Ephemeroptera), Caddis flies (Trichoptera) and aquatic worms (Oligochaeta). The total number of macroinvertebrates collected is given in Fig. 10 while the taxa are given as appendix 1.

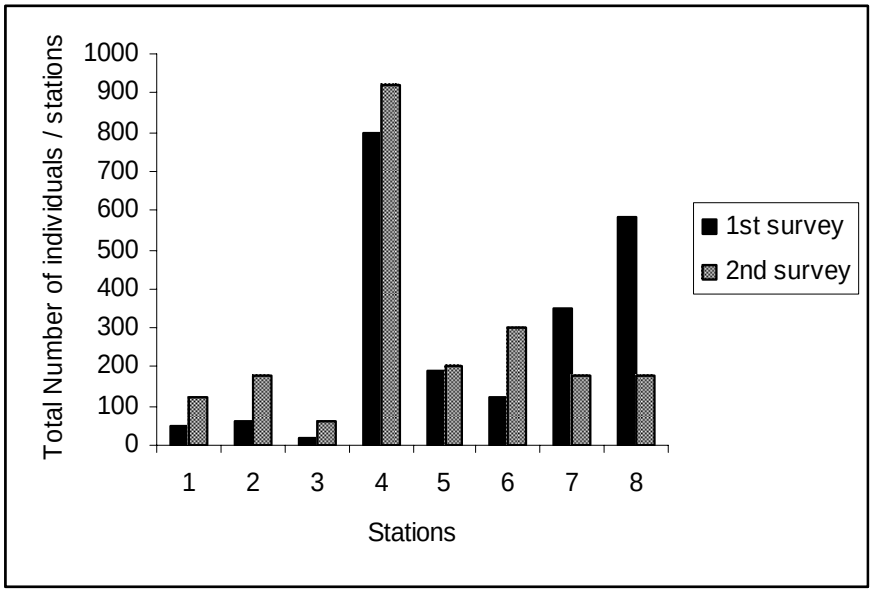


Fig. 10: Longitudinal distribution of the Total number of macroinvertrates along the Nairobi River (Pacini 1989) **NB:** Stations 1 to 4 – Upstream of the museum bridge Stations 5 to 8 – Mid stream below the Museum Bridge

5.3 Mathare River Tributary

The Mathare tributary of the Nairobi river is the most northern and least studied in all aspects. Indeed little is published on its habitat types and biodiversity. The sources of the Mathare and biodiversity is on the North Eastern side of the Kikuyu escarpment and valleys. These valley bottoms and permanent springs are basically agricultural wetlands beyond Uthiru and Kabete towards Tigoni.

5.3.1 Upper section: Head waters of the Mathare River Basin

As is the case with Nairobi the agro-forested Mathare catchments are densely inhabited by natural and agroforest trees composed of Eucalyptus plantations, *Croton, Cyprus, Grevillea*, Bamboo and shrubs of *Lantana camara* amongst others. The main human activities include similarly; Intensive agriculture (Coffee plantations), Animal husbandry, Silviculture, Vegetable farms along rivers, Charcoal burning dense human settlements and quarrying (see Plate 26).

5.3.2 Reservoirs and Wetlands in the Upper catchment

There are a few of natural wetlands that still exist in the Mathare River's basin. The wetlands have been lost to human settlements & drained for agricultural farmlands, buildings and other infrastructural facilities. Some of the plant genera found in the valley bottom wetlands are *Typha* and *Cyperus* sp with Napier grass in the surrounding. The faunal communities include Fish such as *Tilapia*, Catfish, *Barbus* and Mudfish. Birds like Sacred ibis, Cattle egrets, pied kingfisher and African fish eagle are common in the Kangemi/Kabete dams (Plate 27 & 28).

Plate 26: Quarrying activities in the Upper sections of Nairobi River system Near Kikuyu Town leading to creation of artificial dams. These dams act as water points for agricultural and domestic purposes (UoN ASCO, 2005).

Plate 27a **Plate 27b**

Plate 27a & b: Kineme-Kangemi Dam: The water is used by the surrounding slum dwellers for domestic purposes. Little information has been found on the Limnobiology of this dam, however the local residents and personal observation report fish of various species Tilapia, Oreochromis barbus, claria and lebistes as inhabiting this oligotophic dam (UoN ASCO, 2005).

Plate 28a **Plate 28b**

Plate 28a & b: Lower Kangemi dam/ wetland: A source of water for domestic and agricultural activities - fodder for animal husbandry (UoN ASCO, 2005).

Plate 29a **Plate 29b**

Plate 29a & b: Confluence of the Mathare and Gitathuru tributaries near the Belgium Embassy showing indigenous Mathare-Karura forest. The wetland is drained and numerous tree nurseries planted along the road towards Parklands and Nairobi City Park. (UoN ASCO, 2005).

Below the Mathare North section are found a variety of birds and agricultural strips on the banks of the river across the Outer Ring road. Crops of vegetables, Bananas and Sugar canes are common all along to below Oronoco estate and before the confluence with Nairobi River tributary.

Plates 30 and 31 give a pictorial summary of these cropping system and birds (Sacred ibis found in the sewage laden water at the Outer ring road bridge area.

Plate 30: **Plate 31**

Plate 30: Flourishing Banana plantations and other riverine vegetation along the Mathare River banks at outer ring road bridge Dandora area as well as uncontrolled solid waste damping which harbours vermin, snakes & rats etc. (UoN ASCO, 2005).

Plate 31: Below the bridge, **w**ater Birds (Sacred Ibis) in the highly polluted water along Mathare River. Notice the wading birds inside the water collecting frogs, worms and fish. Napier grass is common along the river banks and is mainly used as fodder for animals. (UoN ASCO, 2005).

5.4 General and common Biological communities in Nairobi River Basin Ecosystems

5.4.1 Fishes and other Crustaceans

Fish species (Communities) form an important link in the food web in aquatic ecosystems as food for humans, birds as well as other larger vertebrates. They are useful in maintaining the ecological balance of plankton communities and other aquatic invertebrates.

Fish species in the upper catchment of Nairobi River consist of mainly fish fry, juveniles, and adult fish mainly found in the Ondiri swamp, Kineme, Amharic and Nairobi Dams as well as intermittently along the river riffles, pools and back water pools until one reaches the CBD and lower stretches. These include the *Tilapia* sp., *Barbus* sop., *Poe cilia* sp., *Oreochromis* sp. and *Clarias* sp. Crustaceans include the freshwater crayfish, *Procambrus clarkii*. Fish, fry and juveniles < 3 cm are known to feed on zooplankton thus the abundance of fry and juveniles are likely to reduce zooplankton densities (Mavuti & Litterick, 1991).

Plates 32 to 35 shows images of some of the commoner fish groups/species commonly reported as occurring in the Nairobi Rivers Basin and wetlands. (Seegers *et al.* 2000, Luc de Vos pers. Comm. 2003.)

Plate 32: *Barbus amphigramma* (Family: Cyprinidae)

Plate 33: *Tilapia zillii* (Family: Cichlidae)

Plate 34: *Poecilia (Lebistes) reticulata* (Family: Poecilidae), Mosquito fish

Plate 35: *Micropterus salmoides* (Family: Centrarchidae)

Oreochromis sp. in the Nairobi River are zooplanktivorous. In the lower reaches of the Nairobi River fish species include the *Gambusia* sp., and *Lebistes* sp., which feed on the marginal vegetation and invertebrates. In the Nairobi dam, the current information shows that despite the invasion of the dam by the water hyacinth *Eichhornia crassipes* the presence of fish species is prominent in and along the oxygenated littoral (shoreline) back waters and upstream wetlands. The *Tilapia* sp., *Barbus* sp., *Poecilia* sp., *Clarias* sp., *Oreochromis* sp. and their juveniles represent the fish species commonly found within and above the Nairobi dam as well as Jamuhuri dam as reported by the local people and personal observations (see plates 32, 33, 34 & 35). Exotic Louisiana Crayfish (*Procambarus clarkii*) and crabs (*Potamonautes* sp.) have been observed and reported by residents in most streams and wetlands of the three (3) tributaries. The fish have a mixed diet, as they tend to feed on detritus and on invertebrates mainly chironomids.

Various other species of fish have been recorded as occurring intermittently all along the three river tributaries, in the riverine back waters and main channel, particularly so during and soon after the rainfalls (Table 5).

Table 5: List of Fishes recorded at various times and places in the Nairobi Rivers System and environs (Ref. L. de Vos pers. Comm).

Species	**Family**	**Habitat**	**Status**
Alestes Affinis	Alestiidae	pelagic	native
Amphilius uranoscapus	*Amphiliidae*	demersal	native
Anguilla bengalensis	Anguillidae	demersal	native
Anguilla bicolor bicolor	Anguillidae	demersal	native
Anguilla mossambica	Anguillidae	demersal	native
Aplocheilichthys	Poeciliidae	benthopelagic	native
Barbus intermedius	Cyprinidae	benthopelagic	native
Barbus jacksoni	Cyprinidae	benthopelagic	native
Barbus kersteni	Cyprinidae	benthopelagic	native
Barbus mariae	Cyprinidae	benthopelagic	native
Barbus neumeyeri	Cyprinidae	benthopelagic	native
Barbus palidinosus	Cyprinidae	benthopelagic	native
Barbus zanzibaricus	Cyprinidae	benthopelagic	native
Garra dembensis	Cyprinidae	benthopelagic	native
Clarias gariepinus	Clariidae	benthopelagic	native
Clarias mossambicus	Clariidae	benthopelagic	native
Clarotes laticeps	Bagridae	demersal	native
Ctenopharngodon idellus	Cyprinidae	demersal	introduced
Cyprinus carpio carpio	Cyprinidae	benthopelagic	introduced
Labeo cylindricus	Cyprinidae	benthopelagic	native
Micropterus salmoides	Salmonidae	benthopelagic	native
Nothobranchius cyaneus	Aplocheilidae	benthopelagic	native
Oncorhynchus mykiss	Salmonidae	benthopelagic	introduced
Oreochromis spilurus spilurus	Cichlidae	benthopelagic	native
Poecilia latipinna	Poeciliidae	benthopelagic	introduced
Poecilia reticulata	Poeciliidae	benthopelagic	introduced
Protopterus amphibious	Protopteridae	demersal	native
Salmo trutta trutta	Salmonidae	pelagic	introduced
Schilbe intermedius	Schilbeidae	pelagic	native
Synodontis serpentis	Mochokidae	benthopelagic	native
Tilapia rendalli	Cichlidae	benthopelagic	introduced

5.4.2 Bird Communities

(Harvey, 1997) reported that over 605 species of birds have been recorded resident in Nairobi Urban environs, and that this number is the highest for any capital city in the world. The birds occupy a wide range of habitats and ecological niches. Of those species 103 are wetland birds, 92 forest birds and 80 grassland birds. The rest of the species of birds occupy undifferentiated and modified habitats in the city. The wetland birds inhabit open water in the rivers, dams and sewage treatment ponds. There are water birds that inhabit riparian forest and non-woody macrophytes found at the edges of streams and dams. However it would not be plausible to imagine that these birds do not move out to the surrounding environs and parks (Table 6a & b).

The Nairobi river basin and catchment lies within the flyway of many thousands of migratory birds, including intra-African and palaeartic migrants. A total of 120 species of birds stop over in Nairobi during their northern migration to Europe or southward migration to southern Africa. However, natural habitats have been steadily disappearing in Nairobi and hence the number of birds wintering in the city has been declining steadily over the years. The loss of forests, grasslands and wetlands in Nairobi river system through clearing for agriculture and settlements has negatively affected the resident breeding birds and the migratory birds.

The presence of African Fish Eagles (*Haliaeetus vocifer),* African Darter (*Anhinga rufa) and* Long-tailed Cormorant (*Phalacrocorax africanus)* around Nairobi Dam and Jamhuri Dam as well as in the upper parts of River Mathare, Gitathuru and Nairobi River (Muthangari area) implies that the river system supports some fishes. The presence of fish was confirmed during the UoN Team visits to these habitats. The grassland birds inhabit open grasslands, gardens and seasonal marshes in Nairobi east, especially in the savannah plains in and arround Njiru, Embakasi and the Nairobi City Parks. These open bush habitat species are the most adaptable, diverse and conspicuous birds in the city.

The birds occurring in the Nairobi river system occupy a wide range of trophic levels. They comprise primary consumers, such as grazers (ducks and geese), seed eaters (sparrows, weaverbirds and finches) and fruit eaters (Black and white casqued hornbills and Hartlaub's turaco). They also contain secondary consumers (insectivores such as Black Cuckoo shrikes and Greenbuls as well as carnivores such as Crowned Eagles and Sparrow Hawks). There are also tertiary consumers (vultures, kites and marabou storks as well as other carrion feeders). This trophic diversity reflects a rich mixture of grassland and forest birds. It also implies that key ecosystem functions are still taking place in Nairobi river ecosystem despite the damaging effect of some the human activities.

Marabou storks (*Leptoptilos crumeniferus*) are frequently seen scavenging and roosting all over the city dams. Other bird species noted are summarised in (Table 6a & b).

Table 6a: List of Wetland Resident birds observed in various wetland habitats within Nairobi River basin and its environs (Extracted from Birds of Kenya 1997)

Scientific Name	**Common Name**	**Frequency of observation**
Tachybaptus ruficollis	Little Grebe	Frequent
Phalacrocorax africanus	Long – tailed Cormorant	Frequent
Gorsachius leuconotus	White-backed Night Heron	Rare
Egretta garzetta	Little Egret	Frequent
Mesophoyx intermedia	Yellow-billed Egret	Occasional
Nycticorax nycticorax	Black-crowned Night Heron	Occasional
Ardea cinerea	Grey Heron	Frequent
Scopus umbretta	Hamerkop	Frequent
Ephippiorhynchus Senegalensis	Saddle-billed Stork	Very Rare
Mycteria ibis	Yellow-billed Stork	Frequent
Dendrocygna viduata	White-faced Whistling Duck	Frequent
Alopochen aegyptiacus	Egyptian Goose	Frequent
Anas undulata	Yellow-billed Duck	Frequent
Anas erythrorhyncha	Red-billed Teal	Frequent
Anas hottentota	Hottentot Teal	Frequent
Sarothrura rufa	Red-chested Fluff tail	Occasional
Rallus carulescens	African Water Rail	Occasional
Amaurornis flavirostris	Black Crake	Frequent
Porphryio porphryio	Purple Swamphen	Occasional
Gallinula chloropus	Common Moorhen	Frequent
Actophilornis africanus	African Jacana	Frequent
Charadrius pecuarius	Kittlitz's Plover	Occasional
Charadrius tricollaris	Three-banded Plover	Frequent
Vanellus armatus	Blacksmith Plover	Frequent
Vanellus spinosus	Spur-winged Plover	Rare
Centropus monachus	Blue-headed Coucal	Rare
Alcedo cristata	Malachite Kingfisher	Frequent
Megaceryle maxima	Giant Kingfisher	Occasional
Ceryle rudis	Pied Kingfisher	Frequent
Motacilla clara	Mountain Wagtail	Occasional
Acrocephalus baeticatus	African Reed Warbler	Rare
Acrocephalus gracilirostris	Lesser Swamp Warbler	Frequent
Bradypterus baboecala	Little Rush Warbler	Occasional
Chloropeta natalensis	Dark-capped Yellow Warbler	Frequent
Cisticola erythrops	Red-faced Cisticola	Rare
Cisticola galactotes	Winding Cisticola	Frequent
Estrilda astrild	Common Waxbill	Frequent

Table 6b: Various birds observed in and around the Nairobi dam. (Gichuki, pers. Comm)

Scientific Name	Common Name
Ardeola ibis	Cattle Egret
Ardea melanocephala	Blackheaded Heron
Ardea cinerea	Grey Heron
Ibis ibis	Yellow- billed Stork
Threskiornis aethiopicus	Sacred Ibis
Hagedashia hagedash	Hadada ibis
Leptoptilos crumeniferus	Marabou Stork
Alopochen aegyptiacus	Egyptian Goose
Balearica regulorum	Grey crested Crane
Vanellus armatus	Blacksmith Plover

5.4.3 Occurrence of other Terrestrial Wildlife Communities within the NRB

The wildlife community that has been reported in various documentations (Nature Kenya, 2005) from the Nairobi River Basin is mainly monkeys, birds and insects particularly from the arboretum and the City Park. The parks are a remnant of an indigenous forest, sheltering a diversity of plants and wildlife. Sykes monkeys and baboons are the most common in the city park. The monkeys are dark in colour with a thick collar of white fur, and have a long tail. They feed on wild fruits and leaves in the forest. Baboons and Vervet monkeys which are light grey in colour with a black face (Plates 36a & b). Small forest antelopes, dikdiks, squirrels and several species of mongoose survive in the thick shrubs and thickets. The City parks, Dagoretti and Ngong Forest are also rich in butterflies whose caterpillars feed on the forest trees, shrubs and herbs while the adult butterflies sip nectar from the flowers.

Small mammals and reptiles (snake and lizards) are common in the various forests along the riverine ecosystem of the three rivers and in the wetland areas.

The Nile monitor lizard (*Varanus niloticus*) is commonly seen scurrying around the reeds, rocks and dry parts in the basin upstream and downstream ecosystems. These semi-aquatic reptiles feed on eggs of other reptiles thus ensuring an ecological balance of the biotic communities (Luc de Vos pers. Comm. 2003).

Plate 36a **Plate 36b**

Plate 36a & b: Vervet monkeys and baboons commonly found in the Nairobi Arboretum, City Park, edges of Karura, Ngong and Dagoretti forests and other similar forest ecosystems within the Nairobi River Basin.

5.4.4 Habitat and biodiversity of NRB Wetlands Ecosystems after the Confluence of the 3 Rivers and environs

The wetlands that are found in Nairobi Province may be categorized into four (4) groups. These include seasonal wetlands, artificial or constructed wetlands/dams, rivers and streams, and swamps. Seasonal wetlands may be defined as areas of marshes, swamps, streams, springs, ponds gravel pits and quarries which occur for a specific period of the year and then disappear only to reoccur again at the specific period of the year. They are characterized by occurring only temporarily within specific areas. They are more abundant during the rainy season but dry up during the dry season. They include rock slabs and rock pools, seasonal pools, seasonal springs and seepage areas, and flooded grasslands, marshes and floodplains, (Crafter *et al.,* 1992).

The Nairobi River Basin is dotted with numerous ponds, hollows and depressions, which contain water during the rainy season. The depressions/hollows have been formed in different ways, which include ancient natural pools originating from water flows over the rocks, Murray pits established during construction of the railway, roads and buildings, churning up of the ground by motorists during motor crosses. The hollows range between 1-4 metres in width and less than a meter in depth. These can be found in Kayole, Dandora, Kariobangi, within the basin grasslands are found on the land below the hillsides, especially in the land between Umoja and Kayole. They can also be found in Komarock, Ruai, Njiru and in open grasslands between Nairobi, Dandora and Embakasi (NCST, 2004). The land covered by grasslands is characterized by black cotton soils, which become waterlogged during the rainy season. Studies carried out by Sarnelle *et al.,* 1998 showed the following:-

Grasses growing in these habitats are adapted to withstand flooding during the rainy seasons and excessive drying and cracking during the dry season Common animals found in flooded grasslands include frogs and toads (especially the ones with a short development cycle) birds (ibis, storks, and cattle egrets). These birds feed on the abundant grasshoppers, worms, tadpoles, frogs and toads that colonize these habitats immediately after rains. Other common birds include Yellow-billed ducks, Black Crakes, Egyptian Geese, Sacred ibis, Lesser moorhens and

sandpipers. The tall thick grasses that develop on these wetlands provide a good breeding habitat for Jackson widowbird, Guinea fowl and Ostriches.

The artificial/constructed wetlands are also common in Nairobi. Major ones include water reservoirs and water pans, sewage ponds, quarry pits, and fish ponds. The ecology of some twenty-six small ponds located along 14 km from outer ring road, on Kangundo Road approximately 5 to 15 km South East of Dandora Sewage ponds was studied from January 1990, to June 1991 (Sarnelle *et al,* 1998). These ponds were created by road construction activities several decades ago and are similar to natural savannah ponds in the area. The native vegetation in this area is primarily *Acacia* scrub and grassland, and the major land use is livestock grazing; however, a small amount of subsistence farming occurs towards Nairobi. The climate is hot and semi-arid, with most rain falling in October and November (short rains) and again water from these ponds is drawn for domestic use, and is especially used for watering cattle. In addition, various wildlife species (gazelles, impala, kongoni, and giraffe) use these ponds as watering holes.

These ponds vary greatly in degree of permanence, ranging from ponds, which contain water for only a few weeks after rainstorms that contain water over several years. The ponds have no permanent outlets however; they overflow during extreme rainfall seasons, into the Ngong and Nairobi River for a period.

Concentrations of nutrients and chlorophyll *a*, and densities of zooplankton, macro invertebrates, and fish, varied greatly from pond-to-pond and through time within a pond. During the overflow and flooding fish migrate from the river upstream into some of the ponds thus recolonizing them seasonally. The dominant fish in all ponds containing fish was a small species of *Barbus*; however, *Tilapia zillii, Labeo* sp., and *Poecilia reticulata* were also present in five ponds near Dandora and Njiru.

Zooplankton assemblages in these ponds were dominated by copepods and/or rotifers, although the cladoceran, *Moina micrura,* and ostracods commonly collected in these ponds were planktivorous backswimmers, *Anisops* spp. Fairy shrimp (*Streptocephalus),* clam shrimp, and tadpoles (particularly *Xenopus)* were also collected in some of the ponds. Benthic and littoral macroinvertebrate assemblages were dominated by chironomids, oligochaetes and the corixid *Micronecta,* although freshwater crabs (*Potomonautes* sp.), snails, and a variety of aquatic insects were also collected. Algal assemblages varied greatly from pond to pond and, depending on the pond, were dominated by cyanobacterial filaments, diatoms, flagellates and colonial and unicellular chlophytes. Most ponds consisted of open water overlying mud bottoms; however, littoral fringes dominated by *Cyperus* sp. Within some cases, small amounts of *Typha domingensis* and *Scirpus* sp. were found around some of the ponds.

5.4.5 Sewage Treatment Ponds

Sewage ponds have been constructed within specific areas for the purpose of biological treatment and disposing domestic wastes and waste water. Within the Nairobi River basin, the ponds include the Kariobangi, Kayole sewage ponds, Dandora oxidation ponds. The sewage ponds are constructed specifically to provide for oxidation of domestic effluents before being released to the Nairobi River downstream ecosystem. The sewage ponds are rich in biodiversity, the one at Dandora being the leading. Common birds found within sewage ponds include Grebes, gallinules, coots, jacanas, stilts, avocets, palaearctic ducks, flamingos, Stint, pochards,

ibis, spoonbills, African darter, egrets, terns among others. A number of Hippos and Crocodiles have been reported to have permanent residence in the Dandora ponds and downstream to Athi River.

Plate 37a & b: Blue green algae *Spirulina (Arthrospira) platensis* dominates the phytoplankton of the ponds and is discharged from Dandora Sewage Treatment Works. The Effluent is directly discharged in the Nairobi river system after biological treatment of all the sewage and wastewater from the ca.3.5 million residents of the Nairobi City. The greenish color is an indication the dense concentrations of Blue green algae *Spirulina platensis* which dominates the sewage ponds. There is no effective sewer treatment hence the facility could be acting as a flow through system. The common reeds, Cyperus and Typha thrive unabatedly along the Nairobi River below the Dandora sewage outfall. (NRBP Phase II, UoN ASCO 2003).

The Sewage treatment ponds discharge daily into Nairobi river sewage waste water which is heavily laden with blue green algae *(Arthrospira (spirulina) platensis* and equal amount of nutrients (Plate 37). This causes heavy pollution on the river and its downstream section (NRBP Phase I & II, Ndiritu *et al.*, 2003). The dominant plants include; *Typha* and *Cyperus* whereas subsistence farming involves Arrow roots, Bananas, Sugar cane as well as tree nurseries usually along the river banks utilizing sewer waters. The sewage stabilization ponds are habitats for Hippos, Crocodiles, and migratory birds including flamingos, crested cranes and cattle egrets. After the Dandora Sewage Treatment Works the river flows through open Savannah grasslands characterized by *Lantana camara* and Acacia trees.

6.0 Impacts on the biodiversity attributes of the Nairobi River Systems

All the Nairobi Rivers and streams pass through areas of high human and industrial settlements ranging from individual households, executive estates, slums, factories Central Business district and "Jua Kali" sheds. As a result, these rivers have been heavily polluted and this has resulted to loss of their bio diversity. Apart from the UNEP funded water hyacinth removal project along the dammed section of Ngong River (Nairobi dam), and Ngong Forest no other conservation initiatives have taken place within these rivers systems. This puts most of the species found in them at risk of disappearance due to pollution. However, commendable conservation efforts are in place by various agencies particularly the Nature Kenya, Friends of Nairobi City Park, Nairobi Dam and the Arboretum. (Nature Kenya 2004).

6.1 Forest Degradation

Ngong and Dagoretti Forests and Ondiri/Kikuyu wetlands are the major sources of the Nairobi river. They support a diverse and rich assemblage of biodiversity. They are also important water catchment areas, and have other environmental, socio-economic and cultural benefits to the rural communities living around these areas. Degradation of these ecosystems through conversion for agricultural activities, settlements and urbanization has led to ecosystem losses and fragmentation hence the disappearance of the biodiversity, some of which is endemic. The degradation has also led to increased soil erosion hence turbidity in the river system that affects organisms' biological processes. Use of fertilizers and other types of manure in the catchment leads to nutrient loading causing excessive macrophytic growth in some sections of the river system. Sedimentation and siltation of the rivers leads to impediment of light penetration hence hindering primary productivity. Excessive organic matter production by these macrophytes leads to anoxic conditions that kill fauna and flora. (Pacini Pers Comm).

6.2 Urban Agriculture and agroforestry

Urban agriculture refers to the raising of food crops, horticulture, poultry and other livestock in cities and towns. Such activities are typically conducted in the back and front yards of houses, in public and private open spaces and in other vacant lots. Urban agriculture has gained increasing significance, popularity and advocacy in recent years. Advocates of urban agriculture point out major benefits. And since urban farmers are more likely to be female, urban agriculture contributes to the empowerment of women and is an attractive alternative to informal, poorly paid jobs. Therefore, UN-HABITAT supports temporary use of vacant urban land and plots for agricultural purposes as long as it is not detrimental to health, the environment and economic efficiency, and where there are ample tracts of vacant urban land. This is still the case in a number of Least Developed Countries.

Plate 38: **Plate 39:**

Plate 38: Deforestation and farming activities around Ondiri swamp

Plate 39: Intensive agricultural activities around Ondiri swamp; the origin of Nairobi River. Papyrus and reeds have been lost due to over harvesting at Ondiri swamp. Practicing agriculture on small parcels of land has diminished Ondiri swamp and Farming has threatened the biodiversity of Ondiri swamp.

The upper catchments of Ngong, Nairobi and Mathare Rivers are intensively farmed lands. Most of the farms are smallholder ones with subsistence farming for cereals and pulses. The upper reaches of the Ngong – Motoine river area mostly residential areas of Karen with small back yard garden and lawns and further upstream is the Dagoretti forest.

Farmers in the Ondiri swamp at the source of the Nairobi River use the water to irrigate their land. The upper reaches of the Nairobi River (the Kikuyu township area) are areas of intensive smallholder farms of maize, beans and other crops. Along the riverine edges of the Nairobi River at Kikuyu Springs before the confluence with Nyongara River, there are small-scale farms of Kales, managu, arrowroots and Napier grass. There are numerous large scale flower farms e.g. Magana farm. Downstream there is a clear grading from the subsistence farming into residential properties as well as changes in the soil formation from the red soil to black cotton soils. The lower upper catchment as areas of cereal garden, with arrowroots, maize beans and Napier grass plots dominating.

The Mathare river catchment is however different as its upper reaches are areas of intensive tea and coffee farming all the way to the Nairobi City boundary. The Gitathuru River catchment area also has intensive coffee farming. The scenario in the Nairobi river basin area is repeated as you approach the city with backyard plots of cereals in the areas above the Runda estate and lawns.

Plate 40 **Plate 41**

Plate 40: Land adjoining Ondiri swamp is owned by individual farmers. Soil erosion at the slope adjoining Ondiri swamp due to farming.

Plate 41: Farming of ornamental flowers and vegetables for trade at Ondiri swamp, the source of Nairobi River in Kikuyu. Ondiri swamp has been the source of water for Kikuyu Town and the surrounding areas since the colonial days. Native forest around the swamp has been cleared for agriculture, planting of exotic trees and settlement.

6.3 Wetland degradation

Wetlands are prime targets for reclamation for crop production by farmers within the basins of Nairobi, Mathare and Motoine. Livestock grazing in wetlands has had profound effect on soil structure and vegetation regeneration. Wetlands have also been used as depositories of both solid and liquid wastes generated from settlements, factories and commercial activities.

The Ondiri/Kikuyu swamp on the upper catchment of the Nairobi River, is faced with multiple problems ranging from cutting down of trees by the local community for timber, charcoal and other domestic uses to excessive water abstraction for the City of Nairobi. This has reduced the forest cover around the swamp; loss of habitat for birds, insects, large mammals as well as small mammals. There is serious encroachment on the swamp by farmers who have cleared the swamp to grow crops in the wetland. Crops grown around this wetland include flowers, vegetables, sugarcane, arrowroots, Napier grass, among other crops. These farming activities have led to high salutation rate from the surrounding farmlands hence reducing the water clarity right from the source, release of pesticides (agro-chemicals) into the wetland and the rivers which are lethal to biotic fauna and flora. There is serious harvesting of *Typha* and *Cyperus Papyrus* to feed animals, these plants are characteristic to wetland ecosystems, and hence the swamp is loosing its structure and functions at a fast rate. Water abstraction within and around the swamp may be affecting the water table and therefore the reason for the reduced water flow in the Nairobi River especially over the dry spell.

As the rivers pass through the city of Nairobi, there is intensive cultivation along their banks with arrowroots, Napier grass and sugar cane dominating. The intensive bank cultivation is as a result of the pressure from residential properties, which have moved towards the rivers. Along the Ngong River after its confluence with Motoine River and near the Nairobi dam, there is intensive farming of sugarcane, Napier grass, arrowroots and yams. Along the Nairobi River there is little farming-taking place in the mid-river reaches but there are numerous tree nurseries.

Plate 42

Plate 43

Plate 42: A stream entering Nairobi dam showing massive growth of *Typha* and *Cyperus* which dominate the upper parts of Nairobi dam. This section has been cleared to give room for sugarcane, arrow roots and vegetable farming (UoN ASCO 2005)

Plate 43: Mid sections of Nairobi dam showing some riparian zones which have been colonized by Typha. In the foreground is Water hyacinth which has completely colonized the dam due to nutrient loading from the Kibera slums in the background. Some sections have been cleared for subsistence farming (UoN ASCO 2005)

Kibera slum lies within the mid – reaches with a population between 250 000 to 800 000. It is the largest informal settlement in Nairobi and is located not far from the city centre (Pascale, 1995). Most of the mud and wattle dwellings are located along a wide slope opposite the Motoine River and Nairobi Dam. There are several housing developments for middle-income earners located close to Kibera. Many of the food producers in Kibera have their plots in a large open space across from the river and dam. This open space includes slopes ranging from gentle to moderate and several soil types. If rainfall is adequate, there are two cropping seasons from October to December and April to July. Maize is generally grown during the long rains but some fast maturing varieties can be grown during the short rains. Beans are grown during both seasons. Aside from these two staples, sweet and Irish potatoes, kale, and cowpeas are common crops. Flood-prone areas are planted with cocoyam, bananas, and sugar cane. High value crops such as onion, tomato, and Swiss chard are rarely seen because they are well liked by thieves. A small number of producers irrigate their plots with sewage water. Within the settlement of Kibera, animal production is a common activity that includes chickens, ducks, goats as well as some sheep and pigs.

Plate 44 **Plate 45**

Plate 44: Peri-urban agriculture (sugar cane and bananas) along the river banks on the Outer Ring Road (UoN ASCO 2005)

Plate 45: Farming sugar cane and arrowroots along the riverbanks around Kibera slums (midstream) (UoN ASCO 2005)

At the lower reaches of the river there are many small-scale vegetable farms especially along the rivers and sewer trunk mains. In the residential areas of Umoja and Kayole, there are large maize and bean farms especially in the furrow grounds between the two estates. Along the trunk sewers, there are large vegetable farms of tomatoes, Irish potatoes, kales (sukuma wiki) arrowroots and plant nurseries that are irrigated using the sewer. The farmers block the trunk mains using stones and use the overflowing wastewater for irrigation.

"Peri-urban" agriculture, as used here, refers to farm units close to town that operate intensive semi- or fully commercial farms to grow vegetables and other horticulture, raise chickens and other livestock, and produce milk and eggs. It also includes non-wood forest products, as well as ecological services provided by agriculture, fisheries and forestry. Often multiple farming and gardening systems exist in and near the Nairobi city.

"Urban and peri-urban forestry" have critical environmental functions, besides some food and non-food production functions. Urban agriculture also appears to enhance food security during times of crisis and severe scarcity. Horticulture, mainly vegetable production, has expanded in and around Nairobi city. The broad diversity of horticultural crop species allows year-round production, employment and income. Growers have realized that intensive horticulture can be practised on small plots, making efficient use of limited water and land resources.

The major danger in utilizing waste waters is food contamination by pathogenic micro organisms and outbreaks of water-borne diseases. High health risks associated with the use of untreated or improperly treated sewage water in irrigation is infection from helminths (worms) such as *Ascaris* (nematode) and *Ancylostoma* (hookworm.) Medium to low risk is associated with enteric bacteria and viruses. In general, the evidence suggests that negative health effects are a problem only when raw or poorly treated wastewater is used for irrigation.

One study of urban agriculture in Nairobi showed the land used for farming was 32% private residential land, 29% roadside land, 16% along river banks, and 16% in other publicly owned areas (Memon and Smith, 1996).

6.4 Urban Animal Husbandry

Small-scale rearing of animals by families living inside the cities is usually a common practice around and within the City of Nairobi. Such urban livestock keeping is much more widespread and it consists mainly of low-input production of poultry, small ruminants, pigs, rabbits, guinea pigs sheep, goats, and cattle. These livestock are kept off-plot. They are herded, tethered or allowed to roam freely on land used by agreement or without the landowner's consent. Some of these animals belong to the above-mentioned homeowners, but most belong to landless families: either long-term squatters in densely populated slums, or pastoralists who settle temporarily on vacant land.

For example, in Nairobi the animals are fed on some purchased agro-processing by-products and crop residues. The women process the milk and sell it directly to consumers and the manure is sold as fertilizer to urban growers of vegetables and flowers (personal observations). Some people without animals even grow forage for sale, such as the Napier grass grown around Nairobi to sell to urban livestock keepers (Lado 1990). One of the greatest strengths of small-scale urban livestock keeping is its great mobility and flexibility. It gives value to municipal and private land momentarily not being used for other purposes, making opportunistic use of land in a positive sense.

However, living with livestock in the town also gives rise to problems. As ecologists we know, the proximity of animals to humans increases the risk of transmitting diseases. Manure, dirty bedding material, feed rests and the wastes of animal processing, if not properly handled, can attract flies and lead to water pollution. With more direct sales through informal channels, control of hygiene conditions and food quality becomes impossible, in view of the lack of laboratories and qualified staff in most developing countries. Roaming animals may cause traffic accidents. Neighbours often complain about the noise and odours from livestock in town. All stakeholders will then be in a better position to make wise decisions when jointly planning the use of urban resources for livestock keeping and other sources of livelihood for urban dwellers.

This zone is composed of residential areas including Kayole, Saika, Njiru, and Ruai lying on expansive savannah grasslands. Open grounds, quarrying, slaughter houses; solid waste dump-sites.

6.5 Organic Pollution and Chemical Pollution (NRBP Phases I & II)

6.5.1 Sewage water and other Nutrient Loading

The Nairobi, Ngong Motoine, and Mathare, among other smaller tributaries, have their source on Ngong hills and Dagoretti to the west of Nairobi City. The Rivers pass through areas of high human settlements ranging from individual households, executive estates, slums, factories and "Jua Kali" sheds. As a result, these rivers have been heavily polluted and this has resulted to loss of their good water qualities and biodiversity. Apart from the UNEP funded water hyacinth removal project along the dammed section of Ngong River (Nairobi dam), no other conservation initiatives have taken place within these rivers systems. This puts most of the species found in them at risk of disappearance due to pollution.

Plate 46a

Plate 46b

Plates 46a & b: Blue green algae *Spirulina platensis (Arthrospira)* discharged from Dandora Sewage Treatment Works into Nairobi River and Inks dyes and detergents from factories at the industrial area are discharged without the least concern to environment. Indeed below this point at the enterprise road bridge the Ngong River waters are no longer habitable by any organisms except the pollution tolerant worms (UoN ASCO 2005).

The sewage/wastewater effluent from the Dandora treatment ponds is directly discharged in the Nairobi river system after biological treatment of all the sewage and waste water from the ca.3.5 million residents of the Nairobi City. The greenish color is an indication the dense concentrations of Blue green algae, Arthrospira (*Spirulina) platensis* which dominates the sewage ponds that there is effective sewer treatment, however, the facility could be acting as a flow through system and various times of the year when the input load is high in the rainy season (Plate 46a).

During the NRBP Phase II UoN ASCO (2003). It was established that organic pollution is the most acute problem of the Nairobi Rivers especially during the dry weather due to lack of dilution from precipitation. Organic pollutants originate from informal settlements, sewage treatment plants effluent, burst sewer lines, open solid waste dumping sites and direct sewage discharge from industries. These pollutants lead to increased BOD, which chokes the river system leading to death of aquatic organisms.

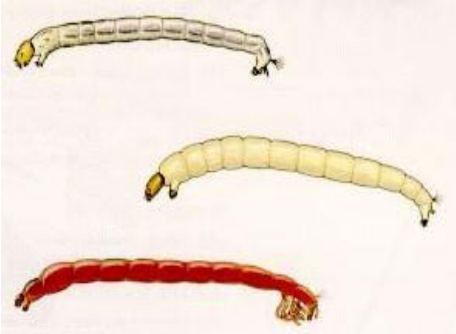
Natural as well as anthropogenic activities are the major sources of nutrients into the Nairobi river system. Natural sources include animal and human waste while anthropogenic sources include surface run off from agricultural land uses, run off from factories and fertilizers from farming activities in the catchment area. Both sources provide nutrients for plant growth in the riparian zone and encrusting algae along the river and substratum. The Nairobi Rivers are characterised by heavy plant growth as a result of increased nutrient input leading to eutrophication of the rivers and their reservoirs. A case in point is the Nairobi dam that is totally colonized by water hyacinth. This hinders the flow of water; light penetration and causes increased BOD, severely affecting the ecology and hence biological diversity of the systems. The water hyacinth has also led to the collapse of the Nairobi river fishery and recreational facilities.

6.5.2 Heavy Metal Pollution

Small quantities of heavy metals are necessary for normal organisms' growth. However excessive levels affect the physiological processes of organisms. They are also a threat to humans utilising water from the rivers for domestic as well as agricultural purposes. Heavy metals have been found accumulated in food crops like kales, arrowroots etc, hence are transferred to human beings where they cause several ailments and deaths . Excessive metal pollutants also lead to increased COD leading to anoxic conditions in the water and sediments. This result to organisms' death and /or changes in community structure and composition. (NRBP Phase II 2003).

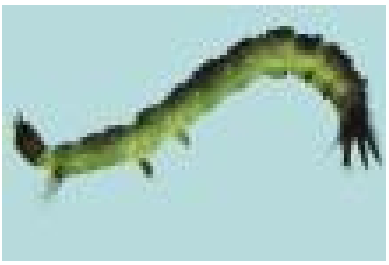
6.6 Benthos as an indicator of pollution

Benthic bioindicators (Fig. 11) are organisms whose presence, absence and types in any ecosystem are used to provide accurate information about the health of that ecosystem (Githunguri, 1991). The term can also refer to an anthropogenically induced response in biomolecular, biochemical or physiological parameters that have been causally linked to biological effects at one or more of the organism, population, community or ecosystem levels of biological organization. The use of bioindicators in ecological studies is referred to as biological assessment or bioassessment. Changes in species numbers, community composition and morphology indicate that the environment is under stress or has become unbalanced. Contaminants such as heavy metals and organic compounds accumulate in tissues of organisms and thus affect their behaviour and health. Appropriate tests on these tissues could indicate the levels of bioaccumulation, and reveal the extent to which organisms (also those that feed on contaminated ones) are affected by pollution.

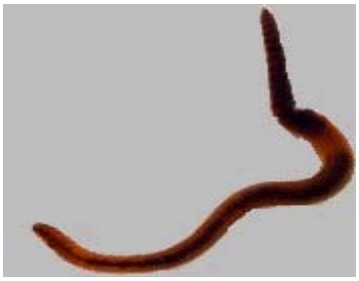


Chironomid worms

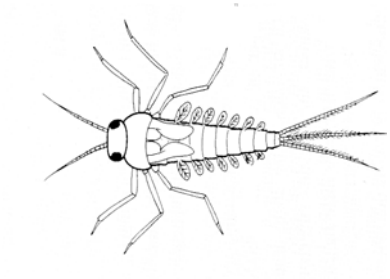
Hirudinea: Leeches



Trichopteran Larva



Oligochaete Worm (*Tubifex* sp)



Ephemeroptera:

Baetidae: *Baetis* sp.

Pouch snail (Mollusca; *Lymnea* sp)

Trichoptera: *Cheumatopsyche* sp.

Caenidae: *Caenis* sp.

Fig 11: Some of the pollution tolerant benthic macroinvertebrates groups collected in the Nairobi River system. All are associated with polluted water. Source: (NRBP Phase II UoN ASCO 2003).

7.0 Conclusions Recommendations and Way Forward

7.1 Conclusions

Despite the rich and diverse biodiversity both indigenous and exotic existing in the Nairobi river basin ecosystems and catchment very little Biological Research has been done. Most of the research concerns and initiatives have been focused on the physiochemical pollutants, water quality, and community benefits derived from the various resources and little on assessment and conservation of Biodiversity.

The available biological information is patchy and uncoordinated. Thus in order to understand the rivers biodiversity and its changes with time, there is need to have a flora and fauna monitoring system, a coordinated data bank, a Standard monitoring protocol and time series biological component research of the Nairobi rivers.

The findings reported were not unique in so far as benthos as indicators of pollution in the Ngong/Motoine-Nairobi River is concerned. It is considered essential to design and conduct studies on the benthic community assemblages along the Ngong/Motoine-Nairobi River system. This information will form a baseline in biodiversity restoration efforts and also in the overall restoration of the water quality. It will also serve as a reference for any other biomonitoring studies along other river systems in Kenya

High nutrient enrichment and sedimentation are known to favor chironomids and oligochaetes as opposed to snails, Trichoptera, Ephemeroptera and Plecoptera. This study revealed that the macroivertebrate communities respond to changes in the water quality and this was seen in the changes in the composition of the various taxa. This was attributed to improper land use practices along the river banks, industrial pollution and residential urban settlements. The EPT taxa coincided with water quality degradation from the catchment downstream and this was seen in changes in the composition of species assemblages, and in biodiversity indices and densities.

These findings were consistent with Connels (1978) explanation that heavily impacted areas have low number of species and high densities due to low inter-specific competition. On the other hand with a decrease in stream stability other macroinvertebrate communities tend to decrease though this does not mean their removal from the habitat.

7.2 Recommendations

7.2.1 Gaps in Knowledge

1. There is lack of consistent information on the nature and trends of pollutants

2. Methods of pollution analysis are variable, thereby making pollution data not comparable both in time and space

3. Biological information available is limited in scope and detail

4. Ecosystem approach to analysis and synthesis of available data, information and environmental issues is lacking.

5. Nairobi River basin initiatives, including research, pollution management and information management have not been centrally co-ordinated

6. City planning processes have not been participatory and take into account only limited environmental concerns and Biodiversity should be considered

7.2.2 Future actions: Research, Monitoring and Management

1. Assess the status of biodiversity of existing forest fragments and wetlands

2. Determine the ecological performance of the larger wetlands with a view to identifying performance indicators for monitoring

3. Determine efficient ecosystem response monitoring indicators amongst the existing micro-organisms, animal and plant communities.

4. Develop biological models that can be used to predict ecological changes and assess impacts of conservation interventions.

5. Develop methods and other tools for monitoring of structural and functional aspects of major wetlands, forest fragments and water reservoirs

6. Evaluate response of wind and insect pollinated plants to specified air pollution conditions

7. Develop a capacity building and eco-tourism programme to promote sustainable utilisation of existing urban biodiversity

8. There is need to seek for more funds to carry out a thorough and complete biological survey within the Nairobi River Basin. This will provide the current status on the biological components in order to fill the existing information gaps established.

7.3 Way Forward

There is need to formulate and implement an ecologically sound management plan in order to secure and conserve the unique and disappearing special habitats such as wetlands and forests and the biodiversity found in those ecosystems. Further there is urgent need to raise the levels of awareness on the importance of biodiversity conservation and to set up a bio-monitoring unit in the University of Nairobi that will provide short, mid and long-term information for the Nairobi River Basin.

Everybody lives downstream of the Nairobi Rivers; conserve them

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APPENDICES

Appendix 1: Names of macroinvertebrate taxa collected along the Nairobi River tributary**.** Source: (Pacini, 1989) (Githunguri 1991)

Order	**Suborder**	**Family**	**Sub-family**	***Genus/Species***
DIPTERA		Chironomidae	Orthocladiinae	
			Chironominae	*Chironomus plumosus*
			Diamesinae	
			Coryneurinae	*Pentaneura*
		Simulidae		*Simulium*
		Ceratopogonidae	Dashyleinae	*Bezzia*
		Dixidae		*Dixa*
PLECOPTERA		Perlidae		*Neoperla*
EPHEMEROPTERA		Baetidae	Baetinae	*Baetis*
		Caenidae		*Centroptilium*
		Caenidae		*Caenis*
		Leptophlebiidae		*Choroterpes*
TRICHOPTERA		Hydropsychidae	Hydrosychinae	*Cheumatopsyche*
COLEOPETRA		Gyrinidae	Enhydrinae	*Dineutus*
			Gyrininae	*Aulonogyrus*
				Orectogyrus
		Dytiscidae		*Phylodites umbrinus*
				Sphaerodema
		Triclanidae		
HETEROPTERA		Hebridae		*Dugesia tigrina*
		Notonectidae	Notonectinae	*Anisops*
ODONATA	Zygoptera	Caenagriidae		*Psudagrion gerstaeckeni*
	Anisoptera	Libellulidae		*Orthetrum caffrum*
	Cordulegasteriidae			*Sympetrum fonscolombei*
DECAPODA		Cambaridae		*Procambarus clarkii*
		Potamanthidae		*Potamoneutes*
OLIGOCHAETA		Tubificidae		*Brachiura sowerbyi*
		Glossoscolecidae		
MOLLUSCA		Buliniidae		*Bulinus*
		Ancylidae		*Burnupia*

Appendix 2: Names of riverine hydrophytes and macrophytes observed along the Nairobi River system. Source: (Pacini, 1989),

FAMILY	SPECIES
Acanthaceae	*Thunbergia alata*
Amaranthaceae	*Achyrantes aspera*
Amaranthaceae	*Amaranthus hybridus*
Araceae	*Colocasia antiquorum*
Araceae	*Pistia stratiotes*
Basellaceae	*Basella alba*
Brassicaceae	*Rorippa nasturtium - aquaticum*
Brassicaceae	*Rorippa madagascarensis*
Cannaceae	*Canna bidentata*
Commelinaceae	*Commelina baghalensis*
Compositae	*Ageratum conyzoides*
Compositae	*Aspilia pluriseta*
Compositae	*Bidens pilosa*
Compositae	*Blumea aurita*
Compositae	*Conyza floribunda*
Compositae	*Crassocephalum picridifolium*
Compositae	*Dichronocephala*
Compositae	*Ethulia scheffleri*
Compositae	*Galinsoga parviflora*
Compositae	*Gnaphalium luteo-album*
Compositae	*Melanthera scadens*
Compositae	*Sphaeranthus napierae*
Compositae	*Tagetis minuta*
Compositae	*Tithonia diversifolia*
Cyperaceae	*Cyperus alternifolius*
Cyperaceae	*Cyperus dichrostachys*
Cyperaceae	*Cyperus immensus*
Cyperaceae	*Cyperus laevigatus*
Cyperaceae	*Cyperus maculatus*
Cyperaceae	*Cyperus papyrus*
Cyperaceae	*Cyperus rigidifolius*
Cyperaceae	*Scirpus confusus*

FAMILY	SPECIES
Euphorbiaceae	*Phyllanthus odontadenius*
Euphorbiaceae	*Ricinus communis*
Fabaceae	*Crotalaria agatifola*
Lythraceae	*Cuphea micropetala*
Marsileaceae	*Marsilea macrocarpa*
Malvaceae	*Pavonia urens*
Onagraceae	*Ludwigia abyssinica*
Polygonaceae	*Polygonum pulchrum*
Polygonaceae	*Polygonum salicifolium*
Polygonaceae	*Polygonum senegalense*
Polygonaceae	*Polygonum setosulum*
Polygonaceae	*Rumex bequaertii*
Poaceae	*Cynodon dactylon integrifolia*
Poaceae	*Echinochloa pyramidalis*
Poaceae	*Pennisetum purpureum*
Poaceae	*Pennisetum clandestinum*
Phyllanceae	*Phyllanthus napierae*
Plantaginaceae	*Plantago major*
Pontederiaceae	*Pontederia lancifolia*
Ranunculaceae	*Ranunculus multifidus*
Solanaceae	*Datura stramonium*
Solanaceae	*Nicandra physaloides*
Solanaceae	*Solanum muritanum*
Typhaceae	*Typha domingensis*

Appendix 3: List of common and widespread 10 trees within Nairobi River Basin. Mathenge Pers. Comm., Dept. of Botany, Herbarium, UoN

Jacaranda mimosifolia, Brazilian Rosewood. A handsome deciduous tree, spectacular in full flower, usually growing upto 15m but occasionally to 30 m., introduced to Kenya early in the century by the Fathers of St. Austin's Mission. **Origin: Brazil**

Acrocarpus fraxinifolius, Indian Ash, Australian Ash, Single Tree. A very tall, fast growing deciduous tree up to 60metres in height with clean, straight trunk and bright red young foliage. Originally introduced in coffee and tea plantations as a shade tree and now widely planted around Nairobi. **Origin: India/ Australia**

Croton megalocarpus, Mukinduri (Kikuyu). A spending upper-storey forest tree to 35 metres or more, usually with a flattish crown and horizontal layers of branches, common around Nairobi. **Indigenous**

Eucalyptus saligna, Sydney Blue Gum. A dense, handsome tree growing to a massive size of 60 metres. **Origin: Costal Eastern Australia**

Eucalyptus macalata, Spotted Gum. Fairly common in Nairobi: a tall tree with distinctive, dimpled stem. **Origin: Eastern Australia**

Grevillea robusta, Silky-Oak. A semi-deciduous tree upto 20m or more with a straight trunk and angular branches very common planted in Nairobi. **Origin: Australia**

Ficus thonningii, wild Fig, Strangler Fig. A large deciduous tree to 21m., often buttressed or multi-stemmed from the growth of aerial roots, widespread in upland forest or open grassland, in Central, Southern and Western regions from 1,000-2,400m. This is the usual species of the Nairobi area. **Indigenous**

Ficus benjamina, Java Fig, Weeping Fig. A dense evergreen tree to 10 or 20m., with attractive drooping foliage, widely planted around Nairobi as an ornamental and street tree. **Origin: India, Malaysia, E. Indies**

Tipuana tipu, Tipu Tree, Pride of Bolivia. A large spreading, semi deciduous shade tree with yellow flowers, growing upto 20m but occasionally to 30m, widely planted around Nairobi. **Origin: Bolivia, Brazil**

Markhamia lutea (Muu, Muho) Kikuyu. An upright evergreen flowering tree with a tall trunk and a high, sometimes irregular crown, usually 10 – 15m., in height, occurring from 1,500-2,000m., around Nairobi. **Indigenous**

City Park

Mostly indigenous forest with *Calodendrum capense* (cape chest nut) *Diospyros abyssinica, Warburgia ugandensis, Brachylaena huillensis* (Silver Oak) *Teclea simplicifolia, Albizia*

schimperi, Schrebera alata, Elaeodendron buchananii, Margarataria discoidea, Markhamia lutea, Olea europaea sp. africana (Wild Olive).

Parklands
Jacaranda mimosifolia, Acrocarpus flaxinifolius, Markamia lutea, Chorisia speciosa, Croton megalocarpus, Croton, macrostachyus, Cuppressus lusitanica, Eucalyptus saligna, Eucalyptus camaldulensis, Eucalyptus paniculata, Ficus thonningii, Grevillea robusta, Ficus elastica. Calodendrum capense, Euphorbia cadelabrum, Filicium decipiens, Podocarpus falcatus, Dracaena steudneri, Schrebera alata, Eucalyptus maculata, Albizia schimperi, Ficus elastica (Indian Rubber.)

Mathare – Muranga Bridge
Saccharum officinurum (sugarcanes), *Mangifera indica* (Mango) *Bambusa vulgaris* (Bamboo) from Himalayas, *Musa sapiens,* (Banana) *Tithonia diversifolia* (wild sunflower that is taking over from *Polygonum senegalensis* at the bank of the river. *Pavonia urens, Ricinus communis, Cyperus dives, Pennisetum purpurea* (Napier grass), *Polygonum pulcherum, Cynodon dactylon* (Star grass) *Ipomoea cairica, Amaranthus hybridus, Solanum nigrum, Trapaelum majus, Amaranthus thunbergii,* (Pigweed).

Mathare Depression Area
Cultivation: *Eucalyptus saligna* (Gum Tree) *Tithonia diversifolia* (Wild Sunflower), *Polygonum pulcherum, Polygonum senegalensis, Spathodea companulata* (Nandi Flame), *Musa sapiens* (Banana)

Mathare Catchment – Kari Bridge
Persea americana (Avocado) *Acacia mearnsii* (Wattle bark) *Hibiscus diversifolia, Cynodon dactylon, Grevillea robusta* (Australian Silky Oak) *Casuarina cunninghamiana* (River She-Oak) *Pennisetum hohenackeri* common *tussocky perennial* with tout compressed culms -60-150cm high. Flood plain and stream banks, *Cyperus incilnata,* (Sedge) *Cyperus dives* (Sedge) common at Kari wetland.

Kangemi Dam
Pinus patula, Pinus radiata, Croton macrostachyus Eucalyptus camaldulensis (Gum Tree) *Typha domingensis, Lantana camara* (Lantana) *Ficus sur, Ficus thonningii*, (Strangler Fig) *Ficus benjamina* (Java Fig, Weeping Fig) *Acacia mearnsii* (Wattle bark) *Musa sapiens* (Banana) *Zea mays* (Maize).

Upper Dam Kangemi
Lantana camara, this invades overgrazed open area, *Pennisetum hohenackeri, Schoenoplectus confusus, Hibiscus diversifolia, Pennisetum purpurea* (Napier grass) *Sphaeranthus suaveolens, Senna didymobotrya, Sida termifolia*.

Ondiri Swamp
Typha domingensis, very common, *Schoenoplectus confusus* common, *Cyperus dives, Vernonia brachycalyx.* Remnant trees on the raised ground *Albizia gummifera, Warkugia Ugandensis, Croton megalocarpus, Dovyalis abyssinica, Cussonia holstii, Prunus africana,* Exotics *Acacia mearnsii, Eucalyptus saligna.*

Upper Dagorreti Forest

Disturbed indigenous forest with *Eucalyptus* plantation. High canopy: of remnant of *Albizia gummifera, Croton megalocarpus, Calodendrum capense, Ficus sur, Ficus thonningii, Shrebera alata, Eleodendron buchananii, Ficus schimperi.*
Lower canopy: *Dovyalis abyssinica, Olea Africana,* Remnant after charcoal burning, *Acokanthera schimperi* (Arrow poison tree) and shrubs and lianas *Pterolobium stellatum, Toddalia asiatica, Vernonia brachycalyx, Rorippa nasturtium – aquaticum* (floating in water) and club moss. *Ctulia abyssinica, Vernonia lasipus, Psiadia punctulata*.

Ngong Forest
Euclea divinorum (Mkinyee Kikuyu), *Eucalyptus maculata, Acokanthera schimperi, Croton megalocarpus, Juniperus procera, Rhus natalensis,* (Red currant) Shrub, *Prunus africana* (Red Stinkwood), *Shrebera alata, Mutuma* (Kikuyu) *Psydrax schimperi, Cussonia holstii, Cussonia spicata.*

Jamhuri Dam
Typha domingensis common, *Cyperus dives, Cynodon dactylolon.* Trees: *Croton megalocarpus, Tipuana tipu, Jacaranda mimosifolia, Casuarina cunninghamiana, Grevillea robusta, Psydrax schimperi, Teminalia mantery.* Shrub and lianas: *Rhus nataleusis Caesalpinia decpetala, Psiadia punclulata, Lantana camara.* New seedling of *Warbugia ugandansis* and *Markhamia lutea* planted between the fence and dam.

Muthaiga and Environs
Acrocarpus flaximifolius (Indian Ash) *Acacia xanthophloea* (fever tree, Naivasha thorn) *Markhamia lutea, Ravenala madagascariensis* (Traveller's Palm), *Strelizia augusta* (Great White Strelitzia), *Ensete ventricosum* (Wild Banana) *Olea europaea, African sp* (Wild Olive) *Croton megalocarpus* (Mukinduri (Kikuyu) *Washingtonia filifera* (Desert Fan Palm, Petticoat Palm), *Roystonia regia* (Cuban Royal Palm) *Phoenix canariensis* (Canary Palm) *Phoenix reclinata, Theretia thevetioides* (Yellow oleander) *Brachylaena huilensis, Eleodendron buchananii, Warburgia ugandensis, Terminalia mantery* (Umbrella Tree from Madag.) *Sapium elliptica, Millettia dura, Albizia gummifera Schinus malle* (Pepper Tree) *Cassia spectabilis, Bridelia micrantha, Markhamia lutea, Newtonia buchananii* (Lianas: *Pterolobium stellatum, Toddalia asiatica.) Melia azedarch,* (Persian Lilac) *Trichria emetica.*

Appendix 4: List of birds recorded in various habitats within Nairobi and its environs within the Demarcated Study Area of the NRBP Phase III extracted and Adapted from Source: Check-list of the Birds of Kenya, 3rd Edition, 2004. NB: Numerous species of migratory birds have been observed occasionally within Nairobi and its environs.

Wetland Resident Birds

Scientific Name	Common Name	Frequency of observation
Tachybaptus ruficollis	Little Grebe	Frequent
Phalacrocorax africanus	Long – tailed Cormorant	Frequent
Gorsachius leuconotus	White-backed Night Heron	Rare
Egretta garzetta	Little Egret	Frequent
Mesophoyx intermedia	Yellow-billed Egret	Occasional
Nycticorax nycticorax	Black-crowned Night Heron	Occasional
Ardea cinerea	Grey Heron	Frequent

Scopus umbretta	Hamerkop	Frequent
Ephippiorhynchus senegalensis	Saddle-billed Stork	Rare
Mycteria ibis	Yellow-billed Stork	Frequent
Dendrocygna viduata	White-faced Whistling Duck	Frequent
Alopochen aegyptiacus	Egyptian Goose	Frequent
Anas undulata	Yellow-billed Duck	Frequent
Anas erythrorhyncha	Red-billed Teal	Frequent
Anas hottentota	Hottentot Teal	Frequent
Sarothrura rufa	Red-chested Flufftail	Occasional
Rallus carulescens	African Water Rail	Occasional
Amaurornis flavirostris	Black Crake	Frequent
Porphyrio porphyrio	Purple Swamphen	Occasional
Gallinula chloropus	Common Moorhen	Frequent
Actophilornis africanus	African Jacana	Frequent
Charadrius pecuarius	Kittlitz's Plover	Occasional
Charadrius tricollaris	Three-banded Plover	Frequent
Vanellus armatus	Blacksmith Plover	Frequent
Vanellus spinosus	Spur-winged Plover	Rare
Centropus monachus	Blue-headed Coucal	Rare
Alcedo cristata	Malachite Kingfisher	Frequent
Megaceryle maxima	Giant Kingfisher	Occasional
Ceryle rudis	Pied Kingfisher	Frequent
Motacilla clara	Mountain Wagtail	Occasional
Acrocephalus baeticatus	African Reed Warbler	Rare
Acrocephalus graciltrostris	Lesser Swamp Warbler	Frequent
Bradypterus baboecala	Little Rush Warbler	Occasional
Chloropeta natalensis	Dark-capped Yellow Warbler	Frequent
Cisticola erythrops	Red-faced Cisticola	Rare
Cisticola galactotes	Winding Cisticola	Frequent
Estrilda astrild	Common Waxbill	Frequent

Forest Resident Birds

Scientific Name	**Common Name**	**Frequency of observation**
Anas sparsa	African Black Duck	Occasional
Accipiter tachiro	African Goshawk	Frequent
Accipiter minullus	Little Sparrowhawk	Occasional
Accipiter rufiventris	Rufous-breasted Sparrowhawk	Rare
Accipiter melanoleucus	Great Sparrowhawk	Frequent
Hieraetus ayressi	Ayres's Hawk-Eagle	Occasional
Stephanoaetus coronatus	African Crowned Eagle	Occasional
Francolinus squamatus	Scaly Francolin	Rare
Guttera pucherani	Crested Guneafowl	Rare
Treron calva	African Green Pigeon	Frequent
Turtur tympanistria	Tambourine Dove	Frequent
Aplopelia larvata	Lemon Dove	Rare
Streptopelia lugens	Dusky Turtle Dove	Frequent
Tauraco hartlaubi	Hartlaub's Turaco	Frequent
Cuculus solitarius	Red-chested Cuckoo	Frequent

Chrysococcyx cupreus	African Emerald Cuckoo	Frequent
Chrysococcyx klaas	Klaas's Cuckoo	Frequent
Bubo africanus	Spotted Eagle-Owl	Occasional
Bubo lacteus	Verreaux's Eagle-Owl	Rare
Strix woodfordii	African Wood Owl	Occasional
Caprimulgus poliocephalus	Montane Nightjar	Frequent
Apoloderma narina	Narina Trogon	Occasional
Ispidina picta	African Pygmy Kingfisher	Occasional
Phoeniculus bollei	White-headed Wood-hoopoe	Rare
Rhinopomastus cyanomelas	Common Scimitarbill	Occasional
Bycanistes brevis	Silver-cheeked Hornbill	Frequent
Pogoniulus leucomystax	Moustached Green Tinkerbird	Occasional
Pogoniulus bilineatus	Yellow-rumped Tinkerbird	Frequent
Lybius leucocephalus	White-headed Barbet	Frequent
Indicator minor	Lesser Honeyguide	Occasional
Prodotiscus zambesiae	Eastern Honeybird	Frequent
Campethera tullbergi	Fine-banded Woodpecker	Rare
Picoides obsoletus	Brown-backed Woodpecker	Occasional
Psalidoprocne holomelas	Black Saw-wing	Frequent
Andropadus latirostris	Yellow-whiskered Greenbul	Frequent
Andropadus gracilirostris	Slender-billed Greenbul	Occasional
Pyllastrephus cabanisi	Cabanis's Greenbul	Frequent
Chlorocichla flaviventris	Yellow-bellied Greenbul	Occasional
Pseudoalcippe abyssinica	African Hill Babbler	Rare
Pogonocichla stellata	White-starred Robin	Occasional
Cossypha semirufa	Ruppell's Robin-Chat	Frequent
Alethe poliocephala	Brown-chested Alethe	Occasional
Cercotrichas hartlaubi	Brown-backed Scrub Robin	Occasional
Turdus olivaceus	Olive Thrush	Frequent
Muscicasa adusta	African Dusky Flycatcher	Frequent
Apalis porphyrolaema	Chestnut-throated Apalis	Rare
Apalis cinerea	Grey Apalis	Occasional
Apalis melanocephala	Black-headed Apalis	Occasional
Apalis jacksoni	Black-throated Apalis	Rare
Apalis pulchra	Black-collared Apalis	Occasional
Sylivietta leucophrys	White-browed Crombec	Rare
Eremomella scotops	Green-capped Eremomela	Rare
Zosterops poliogaster	Montane White-eye	Frequent
Parus albiventris	White-bellied Tit	Rare
Trochocercus albonotatus	White-tailed Crested Flycatcher	Frequent
Terpsiphone viridis	African Paradise Flycatcher	Frequent
Batis molitor	Chin-spot Batis	Frequent
Platysteira peltata	Black-throated Wattle-Eye	Occasional
Dryoscopus cubla	Black-backed Puffback	Frequent
Coracina caesia	Grey Cuckoo-shrike	Rare
Oriolus larvatus	Black-headed Oriole	Frequent
Anthreptes collaris	Collared Sunbird	Frequent
Nectarina amethystine	Amethyst Sunbird	Frequent
Nectarina preussi	Northern Double-collared Sunbird	Frequent
Ploceus insignis	Brown-capped Weaver	Rare

Nigrita canicapilla	Grey-headed Negrofinch	Rare
Cryptospiza salvadorii	Abyssinian Crimson wing	Rare
Mandingoa nitidula	Green-backed Twinspot	Rare
Estrilda quartinia	Yellow-bellied Waxbill	Occasional

Appendix 5: Some of Nairobi City Arboretum and Nairobi City Park (Gichuki, N Pers Com 2005)

Mammals	**Snakes**
Cercopithecus mitis	*Crotaphopeltis holtamboeia*
Cercopithecus Cercopithecus	*Lycophidion capense*
Cercopithecus aethiops	*Philothamnus battersbyi*
	Hemmirhagerrhis hildebrandlik
Lizards	*Typhlops lioleolatus*
	Lamprophus fuliginosos
Gerrhosarol major	*Pasypactice atua*
Chameleo jacksonii jacksonii	*Psammophylax multisquamis*
Hygoson suqulevelli	*Elapsoidea surdevalli*
Gerrhosainol nigrolineator	*Causus rhombeatus*
Mabuya striata striata	*Aparallactus jacksonnii*
Mabuyu magarula	*Dasypeltis scabra*
Acanthlcerus atricollis	*Leptotyphlop scutifarris markeri*
Acanthlcerus cyanogaster	*Elapsoidea loveridgei*
Chamaeleo hohnelii	*Naja nigricollis*
Latistia longicaudata	*Psammophalax multisquamis*
Mabuyu varia	*Causus rhombeatus*
Penapsis wahlbeigu	*Denduoaspis polylepis*
Mabuya Megarula	*Python netalensis*
Hemidactylus mabouia	*Psammophis mosssambiais*
Hemidactylus brookii	*Najehaje*
Leptosiaphos kilimensis	*Micraleps bicularatus*
Mabuya brevicolis	*Bitis arieterus*
	Typhlops orgolensis