Format for the project manual

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Overview of the Project

Wetlands are places that are inundated with water temporarily, seasonally or permanently during a period of one year. These wet places include swamps and marshes, streams and rivers; flood plains and deltas, shallow lakes, dams, ponds and pans. These wetlands cover only a small proportion (4-6%) of Kenya's total land mass. Wetlands regulate stream flows and recharge underground aquifers making water available to people, livestock and wildlife. Water resources are, therefore, very critical to human activities and it is important to consistently monitor the quality of the same.

The Nairobi River ecosystem has been interrupted by the human activities along the river banks such as informal settlement, light industries, broken sewer lines causing water pollution and environmental degradation which have destroyed the river's ecosystem. Various efforts must be made towards restoration of the Nairobi river ecosystem. The project will focus on the upper course of the river under the supervision of the National Environmental Management Authority. The project aims to establish the environmental conditions of Nairobi River The will be undertaken through the use of miniSASS, a framework used to identify the key species of aquatic macro invertebrates the health of the river.

The project aims to collect information through Universities, Colleges and Secondary schools to collect data and foster environmental education and youth empowerment.

The selected schools will be in proximity of a section of the Nairobi river. The information gathered will guide the teams in determining appropriate methods they can use to restore the ecosystem in their region. This will be a major step in gradually restoring the river. It is envisaged that the results of this pilot project will be a basis for replication in replication in the many regions with water bodies to safeguard the countries vast and threatened water resources.

A river is a course of water that originates in the mountains and flows downwards until it reaches the sea. Rivers are of immense importance. They are vital carriers of water and nutrients to other areas. Rivers provide water, food, energy and resources among others. Kenya rivers are distributed in within five drainage basins: the Tana, Athi, Ewaso Ng'iro north, Rift valley and Lake Victoria Basins. Nairobi takes its name from the Maasai phrase "enkare nairobi", which means "a place of cold waters". This implies that Nairobi river has been the lifeline of Nairobi. The Nairobi River Basin comprises of 3 main rivers; Ngong-Motoine River; Nairobi River and;

Mathare River and meanders through Nairobi city and connects to River Athi which flows to Indian Ocean. The restoration process will improve conditions for flora and fauna; ensure high water quality in the river system; provide ecosystem goods and services.

History of miniSASS and its success

MiniSASS is a simplified version of the South African Scoring System, a low technology, scientifically reliable technique for monitoring water quality in rivers and streams. It was developed in the mid 1990's and is based on the sensitivity of the various animals to changes in the environmental condition of the water. MiniSASS was chosen for its reliability and its ease of application, it does not need complex scientific equipment to implement and is easily understood by younger learners as well. It's been widely used in South Africa and has registered immense success.

Aquatic macro-invertebrates have different levels of sensitivity to change in the water conditions. The more sensitive ones will tend to either die or migrate from areas that have experienced changes in the water conditions. Example of such changes includes changes in temperature or levels of dissolved oxygen in the water or introduction of pollutants. Examples of such sensitive species include Stone flies Caddis flies and Mayflies. Some aquatic macro-invertebrates are more resilient and can withstand negative changes in the water conditions thus will be found even in streams and rivers that have poor water quality. Examples of such organisms are snails, flat worms and true flies.

The MiniSASS technology uses the types (composition) and numbers of organisms in a given sample (abundance) of macro-invertebrates in the river to assess stream health.

Problem Statement

The Nairobi River ecosystem has been interrupted by the human activities along the river banks such as informal settlement, light industries, broken sewer lines causing water pollution and environmental degradation, deliberate dumping, agricultural activities causing serious soil erosion and, effluent released into the river before pre-treatment. An aquatic ecosystem refers to those interactions which develop among the living creatures of a given climatic, geological and morphological context along a course of water. We find many different aquatic ecosystems along a river's course, and any interruption or alteration to their composition can cause serious problems indeed. Therefore, the Nairobi River ecosystem is completely interrupted. These issues have resulted from inadequate information about Nairobi River to the public, failure in law enforcement and crime, inadequate education & awareness and a culture of negligence by the public among others. The effect of this interruption which has occurred over the years has caused serious damage to the river ecosystem and those organisms which depended on the river ecosystem for food and shelter. This has totally reduced the significance, importance, health and integrity of Nairobi River which has become a threat to the inhabitants along the river banks causing Health problems such as increased water borne diseases, respiratory complications;

stress on immediate aquatic ecosystems as well as downstream; reduction of the economic value of premises along the river basin and; reduction in the natural beauty of the river basin among others. Therefore, action to resuscitate the Nairobi river ecosystem is inevitable.

The Nairobi River ecosystem has been interrupted by the human activities along the river banks such as informal settlements, light industries, deliberate dumping, agricultural activities and broken sewer lines, releasing effluent into the river before pre-treatment. This has caused water pollution soil erosion and environmental degradation of the river catchment. These human activities have also affected the aquatic ecosystems and disrupted the natural patterns and processes of different species as they do not have the ability to adapt to the rapid changes to their environment.

The interruption of the Nairobi River ecosystem is a result of inadequate information about Nairobi River to the public, failure in law enforcement, inadequate education & awareness and a culture of negligence by the relevant institutions and the public. The effect of this interruption which has occurred over the years has caused serious damage to the river ecosystem and a reduction in the organisms which depended on the river ecosystem for food and shelter. Subsequently, this has resulted in stress on immediate aquatic ecosystems as well as those downstream; reduction of the economic value of premises along the river basin and; reduction in the natural beauty of the river basin.

Additionally, the adjacent populations experience health problems such as increased water borne diseases and respiratory complications among others. Therefore, action to resuscitate the Nairobi river ecosystem is inevitable. Learners in secondary schools and tertiary institutions have studied content on wetlands in Geography and different aquatic life forms in Biology. This pilot project aims at providing a practical approach to river restoration, based on the content taught, through adoption of a section of the river. The project seeks to engage learners in secondary schools, colleges and universities close to the river in the restoration and conservation of the Nairobi River river ecosystems. The project will establish the status of the River with reference to the health of the river and water quality, which will eventually lead to establishment of the gap for the restoration of the river.

Objectives of the Program

The overall objective of the project is to restore the Nairobi river ecosystem.

The specific objectives of the project are:

i. to determine the environmental conditions of Nairobi River using aquatic macro invertebrates.
ii. to introduce the use of miniSASS and the dichotomous key in identification of key wetland health indicator species

iii. To foster environmental education by empowering youth in the Universities colleges and Secondary schools in methods of river restoration
iv. To build the capacity of the youth in secondary schools and universities in using miniSASS and the dichotomous key in identification of key wetland health indicator species

Justification

Given the importance of water resources to human activities it is important to consistently monitor the quality of the same to ensure that they are allocated in the most efficient manner, and pose no threat to human health and welfare. The Nairobi river water cannot be consumed in its present form due to heavy pollution and degradation.

Various topics in the secondary Biology, Geography, Chemistry and Agriculture syllabuses provide the theoretical basis on which this project is anchored. In this project, aquatic macro invertebrates will be used to monitor river health as they are known to be a cheap and reliable means of monitoring water and environmental conditions.

The project provides a practical application of the dichotomous key to identify the key species of aquatic macro invertebrates used in monitoring of river health. The project introduces the use of the miniSASS, a simplified version of the South African Scoring System, which is used in …… This will enhance the learner's knowledge and skills in monitoring river health and determining relevant interventions based on empirical results. The information gathered in this pilot project will provide a basis in guiding policy and community activities championing the restoration and conservation of rivers ecosystems.

Methodology

The project focuses on the aquatic ecosystem of Nairobi River. The initial phase of the study will occur on the upper course of the river. With the assistance of NEMA, the activity points were identified and mapped using Global Position System. The target population is students in secondary and tertiary institutions which are in close proximity to Nairobi River. The sample population will be students involved in Environmental and Wildlife related Clubs. The reporting and analysis framework is based on, MiniSASS is a South African Scoring System that measures the health levels of the river through monitoring the invertebrates in the aquatic ecosystem.

The following steps will be used in project implementation

Step 1: Identification and determination of study area(s). These are points along the Nairobi River. A description of the river conditions should be given and pictures of the area and observable environmental phenomenon taken

Step 2: Obtain the relevant sampling apparatus, including (pond net, white trays, dissecting kit, sampling bottles, hand lenses, dichotomous key).
Step 3: Sampling methods (under miniSASS e.g. rocks, floating part of a plant and water column).
Step 4: Preservation of the identified organisms
Step 5: Take pictures of organisms – invertebrates
Step 6: Record the presence of identified species
Step 7: calculate the average sensitive score
Step 8: Send a copy to (NEMA)
Step 9: Sharing of experiences amongst schools (project team to organize)

Note: the project will be constantly monitored by a project team comprising of NEMA, KICD, KNATCOM, MoEST. A monitoring framework to guide the process has been developed and is attached as Appendix…… An evaluation of the project will beundertaken after 6 months/1 year of implementation.

UNIT TWO: WETLANDS AND HEALTH INDICATORS

This unit provides the focus of the pilot project.

By the end of this unit the learner should be able to:

1. Define a wetland
2. State the significance of rivers
3. Explain how various activities pose threats to rivers
4. Explain the physical, chemical and biological indicators of wetland health
5. Explain why macro invertebrates are used in monitoring wetland health
6. State the importance of river restoration
7. Give examples of the methods use in river restoration.
8. Participate in restoration of the river

Overview of wetlands

Wetlands are places that are flooded with water temporarily, seasonally or permanently during a period of one year. These wet places include swamps and marshes, streams and rivers; flood

plains and deltas, shallow lakes, dams, ponds and pans. These wetlands cover only a small proportion (4-6%) of Kenya's total land mass but they are important as natural sponges that absorb, store and filter water.

Wetlands regulate stream flows and recharge underground aquifers making water available to people, livestock and wildlife.

They absorb rain water and run-off from the adjacent landscape thereby moderating the quantity and quality of water available in rivers and wells. Wetlands also support an enormous variety of plants and animals, some which are economically important to people. The plants include papyrus reeds, sedges, grasses and a wide variety of floating and submerged plants. The animals include small organisms, frogs, fish, reptiles, birds and mammals. Because of their multiple resources, wetlands are magnets for people, livestock and terrestrial wildlife. People living near wetlands exploit the resources to meet their livelihood and economic needs.

Definition of a river

A river is a course of water that originates in the mountains and flows downwards until it reaches the sea. On its perpetual journey, river water crosses land, hills and plains. Starting in the mountains, the water is at first torrential because of rainfall and the melting of ice. Sometimes land levels shift and change abruptly, causing the formation of waterfalls where the water picks up speed and strength. Then, as it reaches the plains, it flows more slowly and if it encounters any obstacles it will flow around them, forming twists and bends (like those of roads) called "meanders".

Significance of rivers

Rivers are of immense importance geologically, biologically, historically and culturally. Rivers are vital carriers of water and nutrients to other areas. They are critical components of the hydrological cycle, acting as drainage channels for surface water. They provide habitat, nourishment and means of transport to countless organisms; their powerful forces create majestic scenery; they provide travel routes for exploration, commerce and recreation; they leave valuable deposits of sediments, such as sand and gravel; they form vast floodplains where many of our cities are built; and their power provides much of the electrical energy we use in our everyday lives. Rivers provide water, food, energy and resources. Rivers are central to many of the environmental issues that concern society.

Distribution of rivers in Kenya

Kenya's surface water resources are distributed within five drainage basins: the Tana, Athi, Ewaso Ng'iro north, Rift valley and Lake Victoria Basins. The following are the five main drainage basins and the rivers within the basins:

1. Lake Victoria Rivers include: the Sio, Nzoia, Yala, Nyando, SonduMiriu, North Awach, South Awach and Gucha-Migori rivers.

2. Rivers in the Rift Valley basin include: the Turkwel and Kerio rivers

3. The Tana basin has: the The Tana River

4. Ewaso Ngiro Basin include: The Ewaso Ng'iro river

5. Athi basin include: The Nairobi river, The Athi River

History of Nairobi River

Nairobi takes its name from the Maasai phrase “enkare nairobi”, which means “a place of cold waters”. At the turn of the 19th Century the Maasai Community habited Nairobi area bordering the present Kiambu County. The area was originally grazing land and a livestock watering point and there was no permanent African settlement. This implies that Nairobi river has been the lifeline of Nairobi.

The Nairobi River Basin comprises of 3 main rivers

- The Ngong-Motoine River
- The Nairobi River
- The Mathare River

The river flows through Nairobi the capital city of Kenya. The rivers join east of Nairobi prior to merging into the River Athi past Thika town and eventually flows to the Indian Ocean. These rivers are characterised by narrow river channels, rapid flow and steep banks with the channel widening and the gradient of the banks reducing as the rivers merge and meander through the landscape past Nairobi towards River Athi.

Activities along the river

The nature of economic activities and settlements along the river changes as the river flows from the source and onwards through the city. Areas near the source such as Kikuyu are mainly agricultural areas with characterised by small scale farming, but as the river approaches the city centre, it is marked by informal settlements along the banks and economic activities such as carwashes and garages. Past the city centre, the river flows past industries and more informal settlements.

Some economic activities pose a threat to Nairobi River. People living in Nairobi’s informal settlements such as slums usually find themselves in the city’s most fragile areas such as flood plains, steep slopes river valleys or adjacent to sewers or dump sites. The rivers receive heavy nutrient loading as they pass through informal settlements such as Kibra (Ngong-Motoine River) and Mathare (Nairobi and Mathare Rivers). They also receive heavy loads of chemical pollutants as they flow through downtown Nairobi (Nairobi River) where garages are located and in Areas such as Mathare and Kariobangi where there are light manufacturing industries.

Wetland health indicators

These are parameters that are used to show the health status of a water body. A healthy wetland ecosystem can be defined as a wetland, including all of its biological, chemical and physical parameters and their interactions that are providing ecological and economic functions.
Examples of such indicators: include biological, chemical and physical indicators.

Some common indicators of wetland health and water quality

Physical indicators	**Chemical indicators**	**Biological indicators**
Bank erosion and stability	Water conductivity	Type and structure bank and aquatic vegetation
Nature of bottom substrate	Water pH	Algae growth and concentration
Water Colour, smell and clarity	Dissolved oxygen	Chlorophyll a and diatoms
Water flow rate	Total dissolved solids	Fecal coliform
Water turbidity	Total phosphorus	Aquatic insects and other invertebrates
Water temperature	Reactive phosphate Total nitrate	Functional structure of communities of fish, amphibians, reptiles, birds and mammals

The use of aquaticmacro- invertebrates in biomonitoring

Aquatic Macro invertebrates are animals that have no backbone and can be seen with the naked eye and they are found in water bodies. These macro invertebrates are used to indicate the health of wetlands for the following reasons:

i. Different macro invertebrates have different sensitivities to pollution.
ii. They are generally easy to collect and identify.
iii. They are relatively inactive which allows the source of pollution to be detected.
iv. They integrate the water quality conditions at a site, providing an overall measure of the "health" of a river.
v. They can provide a picture of the historical water quality at a sit

Some of the commonly used macro invertebrates are as shown in the table below:

Flat worms

Flat worms are characterised by their flattened shape and soft bodied, worm-like form. They have an arrow-shaped head with two dorsal eyespots and are generally mottled or dark grey in colour. Flatworms move with a gliding action and are generally scavengers or carnivores.

Leeches

Leeches are segmented organisms that have very flexible bodies. When moving they expand to become long and thin, and then contract to become short and stubby. They have suckers on both ends of the body that are used for feeding and locomotion. Leeches are variable in colour, from grey, to red brown and black. They swim with a fast, snaking movement and are found under stones, vegetation and debris.

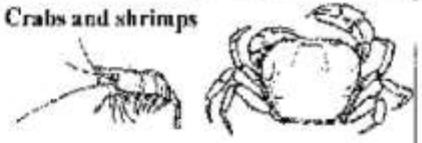
Worms

Worms are long and segmented and have a cylindrical shape much like small earth worms. Their colouring is usually pink to brown. They are usually seen writhing around in debris digesting the substrate they feed on.

Snails

Snails are molluscs with hard shells that vary in size, shape and colour. Habitats vary, with some snails such as limpets clinging to rocks, whereas clams and mussles are found in sand. The more common snails move over stones and vegetation. Some snails are host to bilharzia, a serious health hazard for humans.

Crabs and shrimps

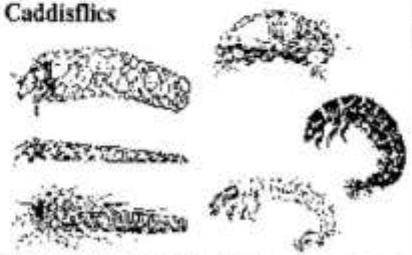


Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs, and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the chance. Shrimps are mostly scavengers or deposit feeders.

Stoneflies

The nymphs of adult stone flies usually have two long tails and three pairs of legs each having two claws at the tip. A characteristic feature of stonefly nymphs are the tufts of gills on the side of the body as well as gills between the two tails. Wing pads on the thorax are often dark and obvious. Some species run across the substrate very efficiently and are potent predators on other invertebrates. Other species are smaller and feed on plant material. Most live in well oxygenated, clean water.

Caddisflies

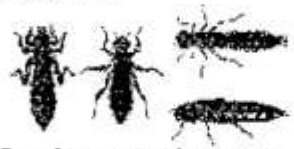


The aquatic larvae of adult caddisflies have a hard head with three pairs of legs which are attached to an elongated, soft body. Finger-like gills on the abdomen and anal appendages can be seen with the naked eye. Some caddisflies construct portable shelters/cases from sand grains, bits of vegetation and/or silk that are glued together to form a characteristic case shape. Most of the case-building types cannot swim whereas the case-less type swim freely across the substrate. Some feed on algae and detritus whereas others are predators.

Damselflies

Damselflies have elongated bodies with generally three broad tails/gills on the tip of the abdomen. Damselflies are carnivorous and have a 'mask' over the lower part of the face which hinges out to reveal a pair of pincers with which they catch their prey. They are often to be found in vegetation growing on the edge of rivers.

Dragonflies



Dragonfly nymphs are robust creatures that are stout and have a large head and protruding eyes. Some have short legs whilst others have long legs. They do not have tails, but swim using 'jet propulsion' by forcefully ejecting water from the abdomen. Dragonfly nymphs are usually the largest organisms found in a sample and are the most powerful invertebrate predators in the water.

Bugs and Beetles

Bugs can be defined as having a piercing and sucking beak for mouthparts, and two pairs of membranous wings. Beetles on the other hand have 'jaws' and outer wings that are hardened to protect the inner wings. Some bugs and beetles are well adapted to swimming, such as water boatmen, backswimmers, pond skaters and water striders. Most bugs and beetles are carnivorous, but some feed on algae.

Mayflies

Mayfly nymphs vary greatly in shape and size and live only for a day or two. In this time they will never feed and live to mate and lay eggs in the water. Mayflies fly close to rivers and lakes, usually swarming in the early evenings.

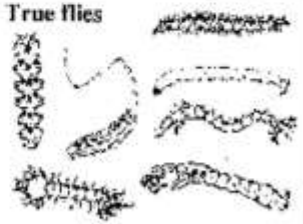
Minnow mayflies

These mayflies have a narrow head and a small, slender, but not flattened body. They have leaf shaped gills on both sides of the abdomen and two but more commonly three tails, depending on the species.

Other mayflies

Other mayflies are characterised by an elongated body, large head, well-developed mouthparts and stout legs. They live in a variety of habitats including burrowing in mud, crawling amongst decaying leaves, and scurrying over stones in fast flowing currents.

True flies



Most fly larvae have a fairly indistinct head but elaborate tail ends. They often have small, soft legs (prolegs), segmented bodies and have the appearance of maggots. Some have bristles/ soinae and antennae. True flies live in a variety of habitats including sand, mud and stones in fast flowing water. They can either be carnivorous or filter feeders.

Restoration of rivers:

River Restoration is the action of improving the health of a river in attempts to take it back to its original state. River restoration is motivated by the degraded states of present day rivers. Habitat restoration is based on the assumption that if adequate physical habitat is available to support flora and/or fauna, then healthy populations should follow.

River Restoration is intended to:

a) Improve conditions for flora and fauna;

b) Ensure high water quality in the river system;

c) Improve the basis for outdoor leisure (aesthetics and recreation).

Strategies and methods of river restoration

Strategies of river restoration include:

a) Education and public awareness: by participating in river conservation campaigns, sensitizing their fellow students and neighbouring communities on importance of river conservation, encourage proper land use practices

b) Reporting incidences of pollution into the rivers to the relevant authorities.

c) Law enforcement by the relevant authorities through arresting the law breakers, Stopping discharges from garages and the informal settlements into the river, Minimize river channelization

UNIT THREE: DATA COLLECTION AND MANAGEMENT

- MiniSASS is a simplified version of the South African Scoring System, a low technology, scientifically reliable technique for monitoring water quality in rivers and streams. It was developed in the mid 1990's and is based on the sensitivity of the various animals to changes in the environmental condition of the water. It's been widely used in South Africa and has registered immense success.
- Aquatic macro-invertebrates have different levels of sensitivity to change in the water conditions. The more sensitive ones will tend to either die or migrate from areas that have experienced changes in the water conditions. Example of such changes includes changes in temperature or levels of dissolved oxygen in the water or introduction of pollutants. Examples of such sensitive species include Stone flies Caddis flies and Mayflies.
- Some aquatic macro-invertebrates are more resilient and can withstand negative changes in

the water conditions thus will be found even in streams and rivers that have poor water quality. Examples of such organisms are snails, flat worms and true flies.

It uses the types (composition) and numbers of organisms in a given sample (abundance) of macro-invertebrates in the river to assess stream health. MiniSASS was chosen for its reliability and its ease of application, it does not need complex scientific equipment to implement and is easily understood by younger learners as well.

How data will be collected

i. Identification of aquatic invertebrates using the dichotomous key

The students will be required to identify and classify various aquatic macro invertebrates using a dissecting microscope and the dichotomous key provided and compile the data obtained in table form.

ii. Compilation of data in miniSASS predesigned sheets.

The students will key in the data obtained from step (i) in the miniSASS predesigned sheets and score the location based on the formula provided.

Average Score = Total Score ÷ Number of groups

iii. Calculation of the miniSASS ecological score

Average Score = Total Score ÷Number of groups

iv. Interpret the score
Based on the score obtained for the site sampled, the health of the site can be determined. The higher the score, the healthier the site.

v. Identify or suggest probable threats and intervention measures

vi. The school and the community can identify threats the possible physical and social economic factors negatively affecting the health of the river and propose solutions.

vii. Dispatch of data summaries to NEMA

viii. The summarised data should then be verified by the teacher or supervisor at school or community level and once deemed satisfactory sent to NEMA for uploading to the overall river health map for Nairobi river.

Procedure for interpretation of river conditions using macro invertebrates (miniSASS)

1. On the table below, circle the sensitivity scores of the identified insects.
2. Add up all of the sensitivity scores.
3. Divide the total of the sensitivity score by the number of groups identified.

4. The result is the average score, which can be interpreted below.

GROUPS	SENSITIVITY SCORE
Flat worms	3
Worms	3
Leeches	2
Crabs or shrimps	7
Stoneflies	14
Minnow mayflies	6
Other mayflies	13
Damselflies	4
Dragonflies	7
Bugs or beetles	6
Caddisflies	9
True flies	2
Snails	4
TOTAL SCORE	
NUMBER OF GROUPS	
AVERAGE SCORE (Divide 'Total' by 'Number of groups')	

4.4 Interpretation of the miniSASS score

- Although an ideal sample site has rocky, sandy, and vegetation habitats, not all
- habitats are always present at a site. If your river does not have rocky habitats
- use the **sandy type** category below to interpret your scores.

Ecological category (Condition)	River Category	
	Sandy Type	**Rocky Type**
Unmodified (**NATURAL** condition)	> 6.9	> 7.9
Largely natural/few modifications (**GOOD** condition)	5.8 to 6.9	6.8 to 7.9
Moderately modified (**FAIR** condition)	4.9 to 5.8	6.1 to 6.8
Largely modified (**POOR** condition)	4.3 to 4.9	5.1 to 6.1
Seriously/critical modified (**VERY POOR** condition)	<4.3	<5.1

UNIT FOUR: MONITORING AND REPORTING.

The purpose of this unit is to:

1. Receive feedback from project implementers (learners)

2. Monitor the progress of the programme

Templates for reports will be developed and provided by NEMA. However, the report should take the form of an experiment, with the following headings:

a) Aims

b) Objectives

c) Achievements

d) Challenges

e) Lessons learnt

The lessons learnt should include possible causes of poor water quality or if the water quality is good then reasons for this should also be given.

The results should be sent to the project coordinating entity (NEMA) for uploading.

NEMA should also authenticate the progress of data collection on the ground.

- Timeframe

UNIT 5 RESTORATION PROJECTS

References

Secondary Syllabus Volume ii subjects mathematics, physics, chemistry, biology agri

Appendix

Dichotomous Key

Macro Invertebrates Classification Chart

Reporting Schedule

Map with Selected Points