Regional training workshop on use of constructed wetlands technology for wastewater treatment, Mombasa, Kenya
18-22 November 2019

Training Workshop Report

29th November 2019
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1 Introduction

1.1 Hosting and representation
Regional training workshop on use of constructed wetlands technology for wastewater treatment, was held in Mombasa, Kenya, from 18th to 22nd November 2019 and hosted by Kenya Marine and Fisheries Research Institute, Mombasa Kenya. The training workshop was jointly sponsored by Western Indian Ocean Marine Science Association (WIOMSA), UNEP Nairobi Convention and Kenya Marine and Fisheries Research Institute (KMFRI). Thirty five participants drawn from Kenya, Tanzania, Mozambique, South Africa, Mauritius, Madagascar, Comoros and Seychelles participated in the training. The training workshop was facilitated by Ms. Sarah den Haring (Green water Environmental water and sanitation solution (Kenya)), Dr Richard Kimwaga (University of Dar es Salaam), Dr. Luke Obala (University of Nairobi), Dr. Eric Okuku (KMFRI) and Mr. Stephen Mwangi (KMFRI).

1.2 Workshop opening session
The opening remarks were given by Dr. Valentine Ochanda (WIOMSA, Cities and Coasts Programme Coordinator), Dr. Jared Bosire (UNEP Nairobi Convention WIOSAP Project Manager) and Dr. Renison Ruwa (Deputy Director Oceans and Coastal Systems Division).

Dr. Bosire informed the workshop that Nairobi convention was implementing a number of GEF funded programs. One of the programs is on Improvement of water quality through which a number of projects on constructed wetlands (CWs) will be implemented in the region. He reiterated the importance of the regional training in building capacity which will be critical in implementation of the various constructed wetlands project in the region. He encouraged experience sharing and using the acquired knowledge in implementations CW projects in various countries. He noted that the training was not an event but a process that is supposed to come up with a solid action plan beyond the training. He further informed the participants of the various technical working groups appointed by Nairobi Convention on the request of the contracting Parties. The working groups include Sustainable management of critical habitats, improved water quality, river flows, marine litter and microplastics. He added that Nairobi Convention was in the process of forming or establishing a technical working group on marine spatial planning.

Dr. Ochanda informed the workshop that WIOMSA is Science based association with the mandate of promoting conservation and improving coastal livelihood through enhancement of research capacity in the WIO region. She noted that Sustainability of cities and their ecosystems will require low cost technology for liquid waste management which can be attained through CW technology. She stressed that there was need for scientists, planners and managers working together for sustainable use of cities-oceans realm. She informed the workshop that cities and coast was initiated by Nairobi Convection following requests by contracting parties. She urged the participants to make use of the knowledge acquired in the training to improve management of aquatic resources.
Dr. Ruwa welcomed the participants to the workshop. He reminded the participants that coastal and marine ecosystems provide goods and services that when sustainably harnessed can be beneficial to communities and a nation. He identified one of the main stressors as discharge of domestic, industrial and agricultural wastes into marine ecosystems resulting in deterioration of water and sediment quality with negative impacts on ecosystem integrity, biodiversity conservation, shoreline stability, community livelihood, and revenue generation. He informed the workshop that there was need to develop ‘green infrastructure’ to manage the ever increasing volumes of domestic and industrial discharge. In this regards, he thanked WIOMSA and Nairobi Convention for partnered with KMFRI to organize the training workshop which will give participants the knowledge and skills to perform basic wetland designs and critically assess existing wetlands as well as establish a network of scientists and managers with interests in utilizing CWS for wastewater management in the region. He thanked Nairobi Convention for approving and funding the redesigning, constructing and operationalization of Shimo la Tewa constructed wetland system whose overall objective is to enhance conservation of marine resources in Mtwapa Creek.

2 Overview of the Training course
The training aimed at 1) giving participants the knowledge and skills to perform basic wetland design and critically assess existing wetlands or wetland proposals and 2) establishing a network of scientists and managers with interests in utilizing CWSs for wastewater management in the region.

The course objectives were to

1. raise and enhance awareness on the status and impacts of marine pollution in the region;
2. highlight various initiatives in combating marine pollution;
3. strengthen the regional capacity in design, operation and management of CWS;
4. raise and enhance awareness on need for urban planning, types of plans and their relevance to coastal cities and/or CWS; and
5. highlight the urban and environmental planning requirements, practice, procedures and processes for Constructed Wetland Systems.

Expected Course outputs were

1. Enhanced awareness on the status and impacts of marine pollution
2. Awareness on interventions to combat marine pollution
3. Enhanced capacity in cost effective technologies to combat marine pollution

The regional training course was jointly funded by WIOMSA Cities and Coasts Program Coordinator, Nairobi Convention’s WIOSAP Project.
3 Course delivery

3.1 Participants expectations

To set the stage for delivery of the training workshop, the participants were given a chance to state their expectations. The following is a highlight of the major expectations from the group:

1. Acquire knowledge and skills on wastewater management;
2. Acquire knowledge on the design, construction and management of CWS and their role in improve the water quality;
3. Understand the best practices in constructed wetlands technology;
4. Understand environmental and social impact assessment of CWS;
5. Create awareness on use CWS for improvement of water quality;
6. Networking with the various stakeholders in constructed wetlands technology;
7. Acquire knowledge and skills on CWS capabilities in pathogen and antimicrobial reduction;
8. Create mechanisms of having CWS as a module in the universities as part of sensitization and capacity building.

3.2 Theoretical session

Theoretical session was delivered in four parts (Annex 3). The main parts included:

1. Status of marine pollution in the WIO region and its impacts on ecosystem and human health;
2. Urban Management and planning;
3. Constructed Wetland Systems (CWS);
4. Various topics were discussed as follows;
   a. Environmental and Social Impact Assessment (ESIA) Impact of CWS;
   b. Constructed Wetland System Operation and Maintenance;

3.3 Group exercises

The participants were divided into five groups and given questions to discuss and present to the meeting. The following were some of the questions:

- What are the barriers to implementation of CWS?
- What are the opportunities for adoption of CWS?
- Explain step by step the process for adoption of CWS?
- Explain how CWS can be incorporated in urban planning?
- Explain the necessary reforms in urban management to facilitate mainstreaming of CWS in coastal cities?
3.4 Field excursions
The participants visited existing Constructed Wetland in Kiembeni and Shimo La Tewa and Mtwapa Creek. The participants were able to

1. learn from what was a success and what went wrong
2. suggest improvement to the existing CW
3. learn about sampling collection for water quality assessment both in the CW and in the receiving water

Figure 2: Kiembeni Constructed Wetland Systems
3.5 Practical session
The participants (in 5 groups) were involved in practical session on the choice of best sand for the CWS. Three types of sand samples namely Sabaki, Malindi and beach sand were used for the exercise.
3.6 KMFRI Laboratory visit
The participants were taken around the various laboratories in KMFRI where sample analysis and quantification are conducted.

4 Observations and recommendations
The following were the key recommendations from the workshop

I. Review the design and operation manuals on Constructed wetlands
II. Create awareness on CWs (e.g having promotional materials for world wetland day)
III. Technical support during implementation of CW projects.
IV. Production of regional status report on CW for shared regional learning
V. Policy briefs on CWs
VI. Create an online platform (e.g. WhatsApp) to further collaboration

5 Closing Session
The training workshop participants were issued with certificates of participation while the facilitators/resource persons were issued with certificates of appreciation after a brief session on course evaluation using course evaluation tool in Annex 5. Closing ceremony remarks were given by Dr. Bosire, Dr. Ochanda and Dr. Ruwa.

Dr. Bosire thanked KMFRI for successfully hosting the training workshop and thanked the participants for being very interactive throughout the sessions. He further thanked the facilitators/resource persons for their technical support and delivering the training and by so doing offering the much needed services in form of expertise and professionalism. He indicated that there are various experts in the region working in different working groups and offering their service for free hence making significant contribution. Dr. Bosire appreciated WIOMSA for the support and close partnership with UNEP Nairobi Convention that resulted not only in actualization of the workshop but also implementation of other programs. He stressed that the workshop is an event and not an end in itself and will be liaising with the facilitators, WIOMSA and other partners in the region to facilitate the key agreed next steps. He finally acknowledged the team involved in hospitality for doing a good job as he wished all safe journey back home as they look for mechanism of promoting the use of this technology.

Dr. Valentine thanked everyone who made the workshop a success. She encouraged everyone to adopt online mode of communication moving forward. She expressed her appreciation on the keenness of the participants and requested that where the expectations are not met, it should be documented for future improvement.

Dr. Ruwa noted that the workshop drew participation from the countries neighbouring the Western Indian ocean with participants coming from different backgrounds including management, policy, academia, research, planning, regulators, service providers, NGOs creating good opportunity to
engage at all levels. He stated that he was confident that the objectives were achieved and that the training gave participants the knowledge and skills to perform basic wetland designs, manage and critically assess existing wetlands. He made an appeal to the participants to establish a network to act as a platform for shared learning and for trouble shooting some of the problems/challenges in constructed wetlands management in the region. For the participants from institutions which will benefit from the WIOSAP demo projects on CWS, Dr. Ruwa encouraged them to now use the knowledge during implementation of their projects. He concluded by thanking the facilitators/resource persons for a job well done as well as the Western Indian Ocean Marine Science Association (WIOMSA) and UNEP Nairobi Convention (WIOSAP) for the financial support that enabled KMFRI organize the training workshop.
### 6 ANNEXES

#### 6.1 ANNEX 1: List of participants

Regional training workshop on use of constructed wetlands technology for wastewater treatment, November 18-22, Mombasa, Kenya

List of Participants

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### 6.2 ANNEX 2: Training Agenda

**Regional training workshop on use of constructed wetlands technology for wastewater treatment, November 18-22, Mombasa, Kenya**

**Training Program**

| Monday, 18th November 2019 | 8.30—9.30 | Registration of participants | Pamela Ochieng  
Esther Goga |
|-----------------------------|-----------|------------------------------|-----------------|
|                             | ✓ Tour de table  
✓ Remarks-WIOMSA (Julius/Valentine)  
✓ Remarks Nairobi Convention (WIOSAP)-Bosire  
✓ Opening remarks - Director KMFRI  
✓ Group photo  
✓ Course objectives, hosting arrangements, logistics and housekeeping announcements (Mwangi, KMFRI) | Mwangi/Okuku |
|                             | 9.30—10.00 | Participants brief presentations on involvement in wastewater management and course expectations | Mwangi |
|                             | 10.00—10.30 | TEA BREAK | |
|                             | 10.30—13.00 | Marine pollution and its impact on human health | Okuku |
|                             | ✓ Types of pollution  
✓ Ecological impacts of pollution  
✓ Pollution impact on human health and economy  
✓ Status of marine pollution in the WIO region  
✓ Marine pollution monitoring | |
|                             | 13.00—1400 | LUNCH BREAK | |
|                             | 14.00—16.00 | Wastewater treatment | SdenH |
|                             | ✓ Wastewater characterization  
✓ Introduction to the nutrient cycle | |
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Presenter(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.30-10.30</td>
<td>CWS Design &amp; Construction</td>
<td>Kimwaga/SdenH</td>
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<tr>
<td>10.00-10.30</td>
<td>TEA BREAK</td>
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<tr>
<td>10.30-11.30</td>
<td>Constructed Wetland Systems, an Introduction</td>
<td>Kimwaga/Obala</td>
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<tr>
<td>11.30-13.00</td>
<td>Environmental and Social Impact Assessment (ESIA) Impact of CWS</td>
<td>Kimwaga/Obala</td>
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<td>13.00-14.00</td>
<td>LUNCH BREAK</td>
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<tr>
<td>14.00-17.30</td>
<td>Visit to Kiambien CWSs site</td>
<td>SdenH/Mwangi</td>
</tr>
<tr>
<td><strong>Tuesday 19th November 2019</strong></td>
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</tr>
<tr>
<td>8.30-10.00</td>
<td>Urban Management and planning</td>
<td>Obala</td>
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<tr>
<td></td>
<td>✓ Overview of the status of coastal urban areas and challenges.</td>
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<td></td>
<td>✓ Urban planning, types of plans and their relevance to coastal cities and/or CWS;</td>
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<tr>
<td></td>
<td>✓ Urban and environmental planning requirements, practice, procedures and processes for Constructed Wetland Systems</td>
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<tr>
<td>10.00-10.30</td>
<td>TEA BREAK</td>
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<td>SdenH/Mwangi</td>
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<tr>
<td>Time</td>
<td>Activity</td>
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<td>10.00-10.30</td>
<td>TEA BREAK</td>
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<tr>
<td>10.30-13.00</td>
<td>✓ Design criteria for different stages (hydraulic and contaminant loading), ✓ Pre-treatment,</td>
<td>Kimwaga/SdenH</td>
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<tr>
<td>10.30-13.00</td>
<td>Material selection, ✓ Gravel/sand procurement, ✓ Logistics, ✓ Site preparation, ✓ Introduction to surveying ✓ Water-proofing materials/techniques.</td>
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<tr>
<td>13.00-1400</td>
<td>LUNCH BREAK</td>
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<tr>
<td>14.00-17.30</td>
<td>✓ Fieldwork</td>
<td>Mwangi/Okuku</td>
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<td>✓ Sea based sampling in Mtwapa creek</td>
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<tr>
<td>Thursday, 21st November 2019</td>
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<tr>
<td>08.30-10.00</td>
<td>Environmental Engineering - Nature Based Systems ✓ Plant-based systems, ✓ Green technologies; and ✓ Specific plants and their uses.</td>
<td>SdenH/Kimwaga</td>
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<td>10.00-10.30</td>
<td>TEA BREAK</td>
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<tr>
<td>10.30-13.00</td>
<td>Recycling Water and water use reduction ✓ When/how to re-use treated effluent, ✓ How to reduce water consumption? ✓ Low flow devices, ✓ Cost benefit analysis - how to calculate; and ✓ Activity planning (short/medium/long).</td>
<td>Kimwaga/SdenH</td>
</tr>
<tr>
<td>13.00-1400</td>
<td>LUNCH BREAK</td>
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<tr>
<td>14.00-17.30</td>
<td>Water samples analysis</td>
<td>Okuku/Mwangi</td>
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<tr>
<td>Friday, 22nd November 2019</td>
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<tr>
<td>08.00-10.00</td>
<td>Shimo la Tewa site visit</td>
<td>Mwangi/SdenH/Okuku</td>
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<td>10.00-10.30</td>
<td>TEA BREAK</td>
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<tr>
<td>10.30-11.30</td>
<td>Practicals ✓ Testing sand to see if suitable for a vertical flow reed bed (essential for good operation of system)</td>
<td>SdenH</td>
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<tr>
<td>11.30-13.00</td>
<td>Group work: Worked examples</td>
<td>Kimwaga/SdenH</td>
</tr>
<tr>
<td>Time</td>
<td>Activity</td>
<td>Participants</td>
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<tr>
<td>13.00-1400</td>
<td><strong>LUNCH BREAK</strong></td>
<td></td>
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<tr>
<td>14.00-16.30</td>
<td>✓ Theoretical simulation of a site, participants to work through and produce a system design in groups</td>
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<td></td>
<td>✓ Plan of action and strategic way forward on use of constructed wetlands in the WIO region</td>
<td>All</td>
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<td>✓ Course evaluation</td>
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<tr>
<td>16.30-17.00</td>
<td>Closing ceremony</td>
<td><strong>Director KMFRI</strong></td>
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</tbody>
</table>
6.3 ANNEX 3: Key highlights of the Theoretical Lectures

Session 1: Status of marine pollution in the WIO region and its impacts on ecosystem and human health

Pollution of various aquatic environment is on the rise from land-based sources along the Coast cities. This is due to increase in human population, urbanization, and industrialization which is characterized by massive utilization of natural resources coupled with an increase in waste production. Many pollutants from these land-based sources like domestic and industrial effluent, oil hydrocarbons, sediments rich in nutrients and pesticides, litter, and plastics and toxic wastes enter the ocean via rivers and surface runoff.

In this session, detailed presentation was given on some of the sources of pollution and their impact on the marine environment. The following topic were covered;

- Types of pollution
- Ecological impacts of pollution
- Pollution impacts on human health and the economy
- Status of marine pollution in the WIO region
- Marine pollution monitoring

Wastewater Treatment Overview

Wastewater discharges from municipal sewage treatment plants as well as uncontrolled effluent into rivers, lakes, coastal waters are a significant source of water quality problems in most of the countries. These pollutants include nutrients, bacteria and other pathogens, heavy metals and organic pollutants from industrial and commercial activities and households. Hence the following topics were discussed in detail;

- Wastewater characterization
- introduction to the nutrient cycle,
- Objectives of wastewater treatment,
- indicator parameters,
- review of various methods of wastewater treatment with their pros and cons,
- Environmental regulations; and
- utilizing design matrix to decide on system type.

Session 2: Urban Management and planning

Urban planning is a technical process concerned with the development and design of land use and the built environment including water supply, wastewater treatment and the infrastructure passing into and out of urban areas. Coastal cities are facing a lot of challenges in coming up with urban plans and some of the process needed were discussed in detail in the following sub-topics
Session 3: Constructed Wetland Systems (CWS)

CWS can be classified according to the presence or absence of water on the surface, (surface/subsurface flow), and the flow direction can be vertical and/or horizontal. There are various types of macrophytes depending on the region and availability. Depending on the macrophytes used constructed wetlands exhibit high removal efficiency for organics and suspended solids while nitrogen removal depends on the type of CWs. Removal of phosphorus is usually low unless special filtration media with high sorption capacity is used. Constructed wetlands are used to treat all kinds of wastewater including municipal sewage, agricultural and industrial effluents, stormwater runoff before being discharged to a nearby water body or reused for irrigation or in aquaculture. Details on CWS techniques were covered under the following topics;

- Types and classification of CWS
- Removal Mechanisms of CWS,
- Advantages and disadvantages of CWS,
- case studies.
- Design procedures
- data collection (water quantity and quality),
- Design approaches,
- Design criteria for different stages (hydraulic and contaminant loading),
- Pre-treatment Requirements for CWS,
- material selection,
- gravel/sand procurement,
- logistics,
- site selection and preparation,
- introduction to surveying; and
- Lining Materials/techniques.
- Construction procedures, techniques and technologies of CWS

Session 5: Various topic were discussed as follows;

1. Environmental and Social Impact Assessment (ESIA) Impact of CWS

The participants were also made aware of the importance of conducting ESIA in any CWS project. Since ESIA is able predict and assess the potential of environmental and social impacts of a proposed project, evaluating alternatives and designing appropriate mitigation, management and monitoring measures. The following topic were also discussed in detail;
• Formation of a planning committee
• Environmental regulations and approvals
• Acquisition of land, social implication of CWS (visual, odour, discharge) and mitigation
• Not my back yard (NIMBY) attitude
• Pollution prevention

2. **Constructed Wetland System Operation and Maintenance**
For efficiency in operation of a CWS, maintenance of the system is vital. The following techniques and methods were discussed in

• Operation and maintenance requirements of CWS
• Vegetation management of CWS
• Gravel Management of CWS
• Inlet and outlet maintenance of CWS
• Treated Wastewater monitoring
• Reuse of treated wastewater and harvested plants

3. **Environmental Engineering-Nature based system**
This involved maximizing nature’s potential of plant-based systems, green technologies; and specific plants and their uses in helping to achieve three main water management objectives: enhancing water availability, improving water quality and reducing water-related risks
6.4 ANNEX 4: Evaluation tool

Regional training workshop on use of constructed wetlands technology for wastewater treatment, November 18-22, Mombasa, Kenya

Workshop Evaluation Form

We kindly request you to answer the questions and indicate your level of satisfaction ticking as either Highly satisfactory, satisfactory (S), Moderately satisfactory (MS), Not satisfactory (NS). We will use the results to evaluate the workshop and to prepare for future collaboration.

General

1. How was the quality and content of information provided before the trip?
   __ HS   __ S   __MS   __NS

2. What do you think about the selection of topics and overall course outline?
   __ HS   __ S   __MS   __NS

3. How was the quality of the presentations?
   __ HS   __ S   __MS   __NS

4. How would you rate the workshop facilitation?
   __ HS   __ S   __MS   __NS

5. How was the conference venue?
   __ HS   __ S   __MS   __NS

6. Were your expectations on the workshop realized?
   __ HS   __ S   __MS   __NS
Outcomes and value

7. In which of the following areas will your participation in this workshop help you promote the adoption of CWs in your country/organization?
   a) Policy and legislation __
   b) Awareness creation __
   c) Design __
   d) Actual construction __
   e) Fund-raising __
   f) Monitoring and maintenance __

8. Do you think that this workshop has prepared you to influence your options in 7 above?
   Yes:
   No:
   May be:
Please briefly explain your answer above:

9. What potential for CWs technology adoption in your country/organization? (Tick the correct one.
   __ Very high __ High __ Low __ Not at all

10. What must be in place to ensure enhanced adoption of CWs technology in your country/organization? (3 key requirements)

11. Would you like further training on CWs technology? If yes, in what area?

12. How did you find the planned field visits and engagement?
   __ HS __ S __ MS __ NS

Networking
13. How did you find the diversity of experience among participants and regional representation?

__ HS __ S __MS __NS

14. Were you able to make networks with potential collaboration beyond the training?
15. Any recommendation for further improvement? Please give one

__________________________________________

Your integrity and follow-up

If you agree to personalize your answers and be available for follow-up, please provide your name. This means that we have your permission to save you name and email.

Name (if you agree)
6.5 ANNEX 5: Examples of certificates of participation, appreciation issued
Certificate of Appreciation

Awarded to

Dr. Richard Kimwanga

In recognition of your contribution as a facilitator/resource person to the success of the Training on Use of Constructed Wetlands Technology for Wastewater Treatment

Organized by Kenya Marine and Fisheries Research Institute (KMFRI) in collaboration with Western Indian Ocean Marine Science Association (WIOOMSA)

18th - 22nd November, 2019, Mombasa, Kenya

Dr. Valantine Ichanda

Dr. Jairy Badiire

Dr. Raphael Bwaye

KMFRI
Certificate of Appreciation

Awarded to

Daniel Odiwuor

In recognition of your contribution to the success of the Training on Use of Constructed Wetlands Technology for Wastewater Treatment

Organized by Kenya Marine and Fisheries Research Institute (KMFRI) in collaboration with Western Indian Ocean Marine Science Association (WIOMSA) and UNEP Nairobi Convention,

18th - 22nd November, 2019, Mombasa, Kenya

Dr. Renison Ruva
KMFRI

Dr. Jared Bosire
UNEP NAIROBI CONVENTION

Dr. Valentine Ochando
WIOMSA