MED-WET

Heliopolis University for Sustainable Development

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

The PRIMA programme is supported and funded under Horizon 2020, the Framework European Union's Programme for Research and Innovation

OPERATION AND MAINTENANCE MANUAL

Constructed Wetlands

Engineering Constructed Instream Wetland Treatment (CWT) Pilot
For isolated rural communities (El-Wahat El-Bahariya), Egypt

February 2024

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Project

Improving MEDiterranean irrigation and Water supply for smallholder farmers by providing Efficient, low-cost and nature-based Technologies and practices Project (MED-WET)

Deliverable Leader

Faculty of Engineering

Heliopolis University for Sustainable Development, EGYPT

Authors

Prof. Wael Khairy (PI) supported by HU Team

Dissemination Level

MED-WET's partner countries

Report Template Design: © Lisa Theuma

Document Version 1: [20 February 2024]

Engineering Constructed Instream Wetland Treatment (CWT) Pilot for isolated rural communities (El-Wahat El-Bahariya), Egypt

1. INTRODUCTION

This operation and maintenance manual (OMM) deals with efficient long-term operation of the Engineering Constructed Instream Wetlands Treatment (CWT) technology at Sekem Farm in El-Wahat El-Bahariya, EGYPT (Figure 1). This manual is designed to provide clear instructions and guidelines to ensure good understanding of the CWT concept, design and operation. It also serves as a comprehensive guide for the proper maintenance and emergency procedures of CWT. The aim is to explain the step-by-step operation of CWT so that can be efficiently produce treated wastewater good for irrigation without risks on human, crop, soil and groundwater. The OMM is structured to provide detailed information about each stage of the CWT, maintenance procedures, control requirements and emergency actions. By following the instructions presented in this manual, users can ensure the safe and reliable operation of the CWT. It contains valuable information about its automated components, installed specifically for Sekem as a large land reclamation agricultural scheme, but not for smallholder farmers in rural areas.

Keywords: Nature-based Solution, Low-cost Technologies, Rural Wastewater Treatment Systems; long-term safe and productive operation, Sustainable Water Management; Combating Climate Change.

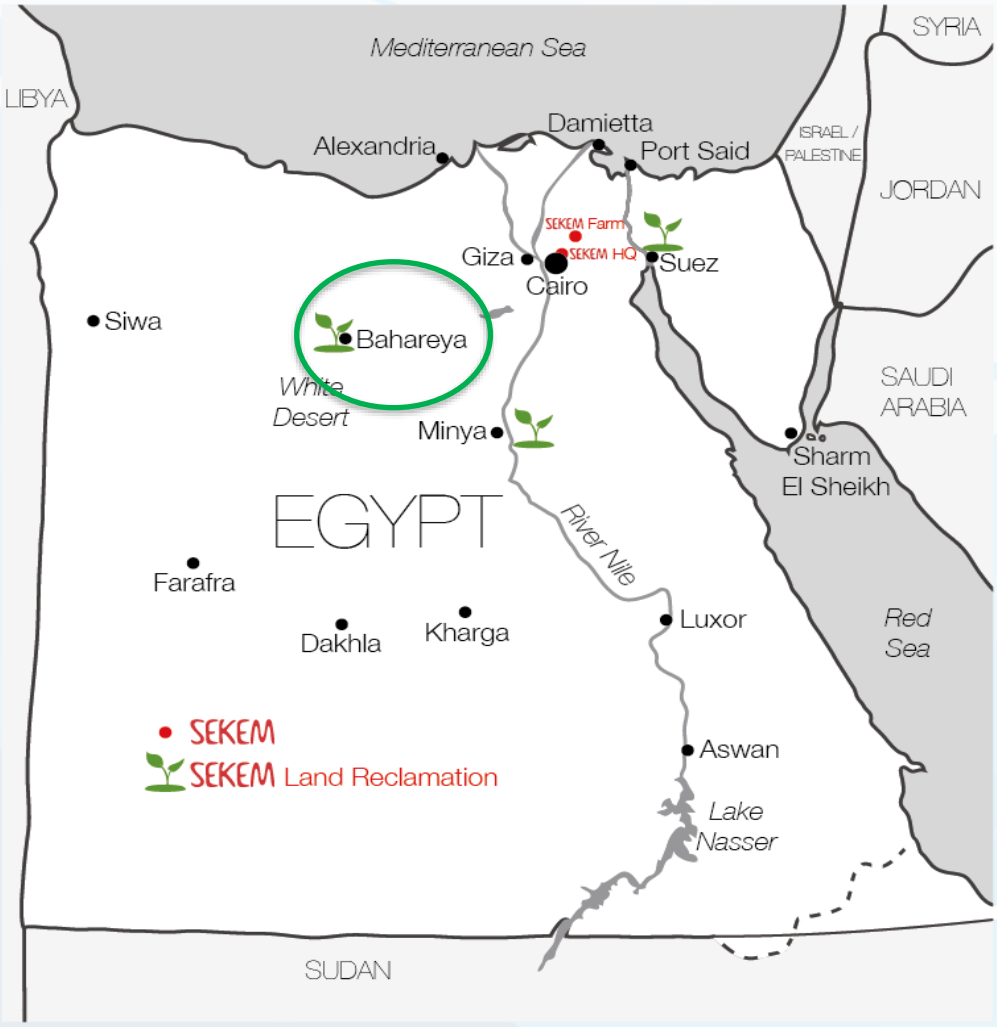

Figure 1. Location of the CWT experimental pilot site in Sekem Farm, El-Wahat El-Bahariya, Egypt

2. AIM

The key objectives of the OMM are: 1) the sustainable operation of the productive pilot (CWT-Model I) at Sekem farm El-Wahat El-Bahariya for reclaiming suitable irrigation water resulting from various wastewater sources (domestic wastewater and agricultural drainage water); 2) starting the upscaling of the (CWT-Model II) at the smallholder farmers communities in isolated areas; 3) providing the farmers with the practical knowledge and technical assistance to adopt, install and operate the CWT system for efficient and sustainable irrigation water and 4) improving the small farms' profitability and the environmental footprint of pilot farming practices.

The scaling-up of CWT technology shall strengthen the farmers' capacity building and urge stakeholder engagement through good linkages with the Egyptian Biodynamic Association (EBDA) as well as Sekem for Land Reclamation (SLR). The target is to serve the isolated desert communities in El-Wahat El-Bahariya. Afterwards; it is planned to promote the low-cost technology for wastewater treatment in other rural communities in Egypt and beyond in the Med-Wet's partners' countries.

3. CONSTRUCTED-WETLANDS TECHNOLOGY – CONCEPT

Constructed-wetlands (CWT) technology treats wastewater naturally by means of soil filtration, aquatic weeds & micro-organisms uptake, natural aeration and sun penetration effect. The experimental development in Egypt follows a gravitational flow (instream wetland system) between upstream and downstream with additional integrated weirs and soil filters. Suitable aquatic weeds and submerged plant species are cultivated in natural substrate to extract specific pollutants and release the inflow of wastewater in cleaner condition. The soil filters as well as micro-organisms capture various chemical and organic pollutants from the wastewater. The sun penetration and aeration in the shallow and slow flow of water kills significant amount of germs, microbes and viruses. The aim is to "clean" the wastewater and produce reclaimed irrigation water that can be used for agriculture. The climatic conditions are quite different despite the Mediterranean location, so each CWT site should be operated independently according to its physical and climatological conditions.

4. Monitoring of Climate, Water, Soil and Crop Quality

The (CWT-Model I) located in a large agricultural scheme called *Sekem Farm for Land Reclamation in El-Wahat El-Bahariya*. It is fenced with galvanized steel so no-one is allowed to enter the CWT site unless authorized to do so. The climate data sets are collected daily or every 10 days according to the nearest weather station's data availability. The climate data sets collected periodically are shown in Table (1).

Table 1. The climate data sets collected periodically from the nearest weather station to the (CWT-Model I) located in Sekem Farm for Land Reclamation in El-Wahat El-Bahariya

Climate	*measurement*	*amount of data*	*measurement cycle*
precipitation	Metrological station	30	Daily or 10-days average
Air temperature	Metrological station	30	Daily or 10-days average
Air humidity	Metrological station	30	Daily or 10-days average

The (CWT-Model I) system is working automatically so no human interference is needed to operate the system. The only authorized human intervention is needed for checking the

normal operation, no troubles or parts malfunction. Also the water quality samples collection for quality assurance is scheduled to be weekly and monthly, as follows:

- Every week: a specialized water quality staff takes two water samples from the two downstream tanks, then deliver them immediately to the in-situ Sekem farm laboratory for basic physical, chemical and micro-biological analysis. In addition, the resident specialist takes immediate water quality indicators during hand-held water quality kit (WQ probes/sensors - WQ Kit 1YSI_ProPlus) as authentication for the laboratory results. Table (2) illustrates the water quality data collected on weekly basis.

Table 2. The basic physical, chemical and biological analysis conducted weekly at the in-situ Sekem farm laboratory

Water quality	*measurement*	*No. of data*	*measurement cycle*
Salts	In-situ	1	once per week
pH	In-situ	1	once per week
cations, anions	Lab at Sekem farm El-Wahat	1	once per week
metals or metal bindings	Lab at Sekem farm El-Wahat	1	once per week

- Every month: HU team visit the CWT site in Sekem El-Wahat El-Bahariya to monitor the (CWT-Model I)'s technical operations, performance and conduct scientific research work to improve the removal efficiency of wastewater pollutants. The Hu team takes immediate water quality indicators during hand-held water quality kit (WQ probes/sensors) as authentication for the laboratory results. Also, the HU team conducts extensive water quality samples collected using disinfected bottles (for biological analysis) and clean standard bottles for the rest of the chemical and micro-physical analysis (in total three bottles per location). The samples are taken from the two upstream tanks and the two downstream tanks (four set of water quality samples, three each with overall total of 12 bottles). The HU team travel back to Cairo immediately in order to deliver the samples (preserved in ice container) to the Atos/Sekem laboratory in Belbies city in about six hours. The laboratory conducts extensive physical, chemical and biological analysis for about 50 parameters, as shown in (Table 3).

Table 3. The extensive physical, chemical and micro-biological analysis for about 50 parameters conducted at Atos/Sekem laboratory in Belbies city every month

Treatment efficiency	*measurement*	*No. of parameters*	*measurement cycle*
Concentrations of supplied wastewater	Lab in Atos/Sekem Belbies	50	average once per month
Concentrations of treated water	Lab in Atos/Sekem Belbies	50	average once per month

The data collection also covers soil sampling and crop sampling. Both are conducted on monthly or seasonal basis based on the crop development and if it is non-fruitful trees or edible crops. Tables 4 & 5 explains the details of soil and crop sampling. Refer to the *Monitoring Plan of the Constructed Wetland Treatment* (CWT-Model I) in Sekem farm, El-Wahat El-Bahariya for further details.

Table 4. The details of soil sampling on monthly/seasonal basis

Soil characteristics via soil samples	*measurement*	*No. of data*	*measurement cycle*
Nutrient/phosphorus contents	Lab at Sekem farm El-Wahat	4	once every 3 months
microorganism excreta	Lab at Sekem farm El-Wahat	4	once every 3 months
composition soil filter (optional)	Lab at Sekem farm El-Wahat	1	Once before irrigation

Table 5. The details of crop sampling on monthly/seasonal basis based on the crop development and if it is non-fruitful trees or edible crops

Crop development	*measurement*	*amount of data*	*measurement cycle*
Growth parameter: type, yield and measuring period?	In-situ	8	average once per month
Physical, thermal, electrochemical and biochemical changes (o	Lab at Sekem farm El-Wahat	8	average once per month

4.1 Typical water quality parameters analysis

Table (6) shows typical water quality parameters collected on monthly basis and analyzed in a certified laboratory in order to estimate the removal efficiency of pollutants and compare it to the Egyptian law. The treated water is used for irrigating productive crops, provided that the quality of that water meets the Egyptian standards for treated wastewater uses (The Egyptian Law for Wastewater Treatment Reuse, ECP No. 501 for 2015) was developed by the Egyptian Ministry of Housing, Utilities and Urban Communities (MHUUC), adopted in 2015. Phase 1 is planned to use the reclaimed water for irrigating various types of non-fruitful trees for carbon sequestration (refer to the *Technical Guidelines and Installation Manual*). Phase 2 comes next to grow Cactus crop as the best selected crop to be irrigated by the treated wastewater, as it can survive in dry weather, can tolerate saline irrigation water and irrigation water shortage. Cactus can tolerate water stress more than trees. The projected Cactus area is about 5.0 ha.

Table 6. Typical water quality parameters collected on monthly basis

Physicochemical parameters

Parameter	Sym	unit
pH	-	
Carbonate	C03	mg /l
Bicarbonate	HC03	mg/l
Total Alkalinity		mg/l
Electrical Conductivity	EC	mmhos/cm
Total Dissolved Solids	TDS	mg/l
Total Suspended Solids	TSS	mg/l
Turbidity	Tur	NTU
Ammonia	NH3	mg/l
Biological oxyegen demand	BOD	mg/l
Chemical Oxygen Demand	COD	mg/l

Major cations

Calcium	Ca	mg/l
Potasium	K	mg/l
Magnesium	Mg	mg/l
Sodium	Na	mg/l

Major anions

Flouride	F	mg/l
chloride	Cl	mg/l
Nitrite	N02	mg/l
Nitrate	N03	mg/l
Phoshate	P04	mg/l
Sulfate	S04	mg/l

Trace Metals

Aluminum	Al	mg/l
Antimony	Sb	mg/l
Arsenic	As	mg/l
Barium	Ba	mg/l
Cadmium	Cd	mg/l
Chromium	Cr	mg/l
cobalt	co	mg/l
Copper	Cu	mg/l
Iron	Fe	mg/l
Lead	Pb	mg/l
Manganese	Mn	mg/l
Nickel	Ni	mg/l
Selenium	Se	mg/l
Tin	Sn	mg/l
Vanadium	V	mg/l
Zinc	Zn	mg/l

Microbiological Parameters

Total Coliform	CFU/100ml
Fecal Coliform	CFU/100ml

4.2 Water quality tools and equipment

The hand-held water quality kit is essential for validation and fast in-situ water quality estimation of the basic parameters (for example: Temp, DO, EC, TSS & TDS). The acquisition of a reliable hand-held water quality kit for in-situ analysis at (CWT-Model I) in Sekem El-Wahat El-Bahariya took time and caused some delays in starting the regular water quality analysis. Because of the high prices of new hand-held water quality kit, HU decided to repair one original and good set of water quality kit (Professional plus WQ Kit) in the amount of 35,683 EGP (equivalent to about 793 Euro). HU team trained a number of research assistants and technicians on how to use the WQ Kit to estimate the basic water quality parameters in-situ using the hand-held water quality kit. Figures (2 to 4) describes the tools and kits used for the water quality analysis in-situ and in the laboratory.

In addition, gather all required tools, equipment and materials for water quality sampling. Also First aid kit and gloves, alcohol spray and clean towels are necessary for the in-situ work. Ensure all disinfected water bottles are available and the ice container is ready with ice inside to travel all distance to Atos/Sekem laboratory in Belbies.

Figures 2. Demonstration of the Professional Plus water quality in-situ kit components and tools used for the water quality analysis

Figures 3. Demonstration of the remaining Professional Plus water quality in-situ kit components, tools and solutions used for the water quality analysis

Figure 4. Equipping the in-situ water quality laboratory in Sekem farm El-Wahat

4.3 Safety Measures at the CWT Site

- Electricity: always ensure that any electrical connections are maintained under the supervision of a certified electrician. Ensure that the power is turned off when working with electrical components.
- Handling: handle all components, especially sensitive ones like sensors with care.
- Avoid submerging sensors or other components that are not water-resistant. Keep them as clean and dust free as possible.
- Protective Gear: wear appropriate protective gear, especially when handling saline water.
- Basic Protection like glasses and gloves are recommended.
- Chemical Exposure: always be cautious when working with or near chemicals, ensuring that they are stored and handled safely.

5. SITE SETTINGS AT OPERATION

Noting that the (CWT-Model I) site is 450km from Cairo where HU premises is located. The HU team have to contract two resident specialists at Sekem El-Wahat El-Bahariya on part-time basis to follow-up the (CWT-Model I)'s operation, maintenance and data collection (water quality, soil and crop) on weekly and monthly bases.

5.1 Observations and Actions to be taken during the (CWT-Model I)'s Operation and Maintenance

During the (CWT-Model I)'s operation, a number of technical observations/problems could arise and the proper actions should be taken to overcome those technical problems. The following actions also apply as regular maintenance work at the CWT site, as shown in Table (7).

Table (7): Operation and maintenance observations and actions to be taken to overcome those observations (CWT-Model I)

Technical challenges	Actions to overcome
The upstream tanks (2) are less than one-third volume full during the day	Check the sensor to make sure that the two upstream tanks are at least one-third volume full at any time during the day.
Inflow discharge does not fulfil the condition of 15-16 liter per minute	Adjust the upstream valve/s so the specified flow discharge can move downstream
No uniform flow along the cross-sectional area of each cell	Clean the wide perforated pipes at the upstream to ensure uniformly distributed wastewater flow along the cross-sectional area of each cell
Lining sheets breaks or leakage	Immediately call the manufacturing company to fix this problem to stop the groundwater pollution
Silts leaks into the flow meters	Fix the fine screen mesh pieces to be well-wrapped at the upstream pipes inlets to prevent the silt particles clogging
Leakages from underneath the freeboard crested weirs	Check and fix the insolation and water-stopping materials that is installed underneath the weir/s
Water falling from above the freeboard crested weirs touching the walls without enough mixing and aeriation process	Check and fix the stainless-steel sheets that is installed above the freeboard crested weir/s in order to allow for more mixing and aeriation
Small shrubs and dry wooden stems move and fall inside the treatment cells due to the high wind	Remove those objects and check the stainless steel mesh fence that is installed surrounding the CWT site as a secured area with controlled entrance gate.
The flow inside each cell does not fulfil the estimated Hydraulic Retention Time (HRT = 3.0 days) so that the treated water outflow is not around 15 m^3/day	Check the segments of treatment if there are any obstacles and fix this key criterion to permit specific discharge accumulates the outflow of treated water to be about 15 m^3/day/cell.

Windblown fine sand precipitate inside the four tanks	All four tanks to be covered and cleaned regularly.
The gravel, basalt and course sand filters are not properly catching the whole flow of wastewater.	Adjustments to be made in the setup of the gravel, basalt and course sand filters so as to ensure high screening efficiency of suspended solids.
Aquatic weeds die off quickly	Increase the substrate layers of native soils.
Leakage is noticed in few fittings or connections	Fixed properly
Site landscape needed enhancements	Fix properly
The operation instructions/rules signs are missing	To be hanged on clear and fixed stands inside the CWT site.
The site protections, guidance and cleaning is poor	Guiding signs and warning/instruction signs to be fixed clearly.
Problem in filling and emptying's automated system	Immediately call the specialized team to fix the problem
Problems in the operation of the photovoltaic panels/solar system	Immediately call the specialized team to fix the problem

5.2 Regular Daily Operation of the (CWT-Model I)

5.2.1 Domestic sewage water treatment unit

- Inlet tank 1 (over-ground) – Cell 1: full of domestic sewage water from the Sekem Farm's hotel, residents and workers' rooms, the cafeteria, the mosque and the administrative area.
- Cell 1 (dedicated for the domestic sewage water treatment): starts with a pipe connection the Inlet over-ground tank (1) to the manual valve and then discharge meter to control the inflow of row domestic wastewater according to the design discharge (15-16 litter per minute).
- Horizontal crossing perforated pipe to assure uniform distribution of the domestic wastewater over the cross-section area of the cell.
- Gravel and coarse sand filters: in which initial filtration process occurs to stop the progressing of fine suspended particles by trapping them forming a micro-film layer of very small organisms, leaving the domestic sewage water in a cleaner condition.
- Sedimentation Tank: about 19 meters' length ending by a 1.0 m height sealed concrete weir. In this segment the large and heavy suspended particles deposit to the bed of the tank.
- Flow over weir for mixing oxygen into the domestic sewage water reducing the BOD and Cod concentrations. This process improves the quality of domestic sewage water by reducing all types of micro-biological loads.
- Aquatic weeds segment: in this segment concentration of all types of salts as well as heavy metals can be reduced significantly due to plants update and soring those materials in its tissues.
- Flow over the 2nd weir for mixing oxygen into the domestic sewage water reducing the BOD and Cod concentrations. This process improves the quality of domestic sewage water by reducing all types of micro-biological loads.
- Coarse and fine sand filters: in which a second filtration process occurs to stop the progressing of the very fine suspended particles by trapping them forming a micro-

film layer of very small organisms, leaving the domestic sewage water in a cleaner condition.

- The domestic sewage water moves to the Azolla algae segment, in which the majority of the carbonic substances and organic pollutants is abstracted as food for the Azolla leaving the water in cleaner condition.
- The 3rd fine sand filters segment: in which a third filtration process occurs to stop the progressing of the micro fine suspended particles by trapping them forming a micro-film layer of very small organisms, leaving the domestic sewage water in a cleaner condition.
- Along the whole cell, the sun rays penetrate the shallow depth of water (0.6 m maximum) killing various types of germs, protozoans, pathogens and microbes.
- The journey of domestic sewage water takes about three days to reach between the inlet to the outlet via the gravitational force, then forming the treated water.
- Outlet 1 Tanks (1): the treated water then being collected in that tank, ready for irrigation trees or crops (about 15-16 cubic meters of irrigation water per day).

5.2.2 Agricultural drainage water treatment unit

- Inlet tank 2 (over ground) – Cell 2: full of agricultural drainage water from the Sekem Farm's pivots and drip irrigation fields.
- Cell 2 (dedicated for the agricultural drainage water treatment): starts with a pipe connection the Inlet over-ground tank (2) to the manual valve and discharge meter to control the inflow of agricultural drainage water according to the design discharge (15-16 litter per minute).
- Horizontal crossing perforated pipe to assure uniform distribution of the agricultural drainage water over the cross-section area of the cell.
- Gravel and coarse sand filters: in which initial filtration process occurs to stop the progressing of fine suspended particles by trapping them forming a micro-film layer of very small organisms, leaving the agricultural drainage water in a cleaner condition.
- Sedimentation Tank: about 19 meters' length ending by a 1.0 m height sealed concrete weir. In this segment the large and heavy suspended particles deposit to the bed of the tank.
- Flow over weir for mixing oxygen into the agricultural drainage water reducing the BOD and Cod concentrations. This process improves the quality of agricultural drainage water by reducing all types of micro-biological loads, if exist.
- Aquatic weeds segment: in this segment concentration of all types of salts (specially salinity) as well as heavy metals can be reduced significantly due to plants update and soring those materials in its tissues.
- Flow over the 2nd weir for mixing oxygen into the domestic sewage water reducing the BOD and Cod concentrations. This process improves the quality of agricultural drainage water by reducing all types of micro-biological loads.
- Coarse and fine sand filters: in which a second filtration process occurs to stop the progressing of the very fine suspended particles by trapping them forming a micro-film layer of very small organisms, leaving the agricultural drainage water in a cleaner condition.
- The agricultural drainage water moves to the Azolla algae segment, in which the majority of the carbonic substances and organic pollutants is abstracted as food for the Azolla leaving the water in cleaner condition.

- The 3rd fine sand filters segment: in which a third filtration process occurs to stop the progressing of the micro fine suspended particles by trapping them forming a micro-film layer of very small organisms, leaving the agricultural drainage water in a cleaner condition.
- Along the whole cell, the sun rays penetrate the shallow depth of water (0.6 m maximum) killing various types of germs, protozoans, pathogens and microbes, if exists.
- The journey of agricultural drainage water takes about three days to reach between the inlet to the outlet via the gravitational force, then forming the treated water.
- Outlet 2 Tanks (2): the treated water then being collected in that tank, ready for irrigation trees or crops (about 15-16 cubic meters of irrigation water per day).

6. CWT'S AUTOMATION SYSTEM FOR GREEN OPERATION

HU increased its in-kind contribution to MED-WET in order to install an automatic control system to allow continuous filling and emptying of the CWT's four tanks without human intervention. The following electrical parts are currently operational with high precision: Inverter 5.0 K. Volt, 10 Photo-Voltaic (PV) solar panels, Steel frame for the PVs, four dry ultra-lithium rechargeable batteries (high voltage), four water level sensors, four pumps 2.0 HP each and connecting wires are auxiliary parts. The automated operation system depends on renewable photovoltaic energy from the sun, so that it is considered green operation. Figure (4) illustrates the (CWT-Model I)'s final layout and configuration during operation.

Figure 4. The final equipped (CWT-Model I)'s layout and configuration during operation

7. ASSESSING THE CWT'S POLLUTANTS' REMOVAL EFFICIENCY FOR SAFE AND SUSTAINABLE TREATED WATER REUSE IN AGRICULTURE

The current water quality monitoring program includes more than 40 parameters estimated in the certified Atos/Sekem laboratory with frequency of one month (this includes physical properties, cations & anions, salts, heavy metals (e.g., Fe, Cu, Mn), BOD, COD, Fecal coliform, E. Coli bacteria, pathogens, viruses, and water-borne diseases). List of the monthly extensive analysis (physical, chemical, micro-biological, and heavy metals) is shown in Table (6) above. The weekly quick water quality includes: pH, EC, DO, TSS, TDS and salts (cations and anions) analysis, done in-situ at the water quality laboratory at Sekem Farm El-Wahat El-Bahariya. The aim of water quality analysis is to conduct a technical comparative research to determine the optimum treatment scenario that leads to the highest treatment efficiency, it is planned that this research work takes one year till the mid of 2024. In addition, the HU team takes and analyses crop tissue and top soil layers' samples to ensure healthy and sustainable ecosystem while irrigating the trees and other crops with reclaimed treated wastewater.

The pollutants' overall removal efficiency is estimated as the summation of percentages of residual pollutants after the treatment divided on the summation of same pollutants before treatment. The indicative overall pollution removal efficiency (CWT treatment efficiency reached 90%) in the beginning of 2024. The grade of treatment using the (CWT-Model I) is derived by comparing the percentages of residual pollutants after the treatment to the threshold values (maximum allowable concentrations) of the same pollutants in the Egyptian Code of Practice for Wastewater Treatment in Agriculture (ECP 501 for 2015). So far, the (CWT-Model I) produces treated water of grade (B) according to the (ECP 501 for 2015), which is suitable for irrigating wood trees and non-edible crops. During the rest of 2024, HU team shall conduct extensive scenarios to improve the water quality of the treated effluent of (CWT-Model I), so the resulting water can be used for irrigating edible crops (but neither vegetables nor fruits), such as fiber, cereal and pulse crops.

8. EMERGENCY PROTOCOLS AND CONTACTS

While the CWT is operational safely and efficiently, unforeseen circumstances or malfunctions may arise (Table 7 above). In such situations, it's crucial to have a well-defined set of emergency protocols and a list of relevant persons contacts to address the situation promptly and minimize potential damage.

8.1 In Case of Equipment Malfunction

1. Immediate Shut Down: If any component or equipment shows signs of malfunction within the site of the CWT at Sekem El-Wahat, such as unusual noises, excessive heat, or smoke, immediately shut down the CWT electrical equipment and close all valves.

2. Avoid Direct Contact: Do not touch any equipment that appears to be malfunctioning or overheating. Wait for it to cool down or for a professional to assess the situation.

3. Isolate the Area: Cordon off the affected area to prevent any unauthorized or uninformed individuals from coming into contact with malfunctioning equipment, inside the CWT site in Sekem El-Wahat. Information signs "action upon emergency with contacts" is needed at the (CWT-Model 1) and at the Bamboo fields and Cactus fields irrigated with the treated

wastewater. It is important not to have direct contact with the irrigation water thus to avoid the possible transmission of any remaining harmful effects in such treated wastewater.

8.2 In Case of Structural Damage

1. Evacuate: if there's any sign of structural damage to the CWT at Sekem El-Wahat, such as cracks or collapses in water tanks, ensure everyone inside the CWT site is safely evacuated.
2. Inspect and Repair: once the area is secured, conduct a thorough inspection to assess the damage. Seek professional assistance for any necessary repairs.

8.3 In Case of Electrical Issues

1. If you suspect any electrical malfunctions, immediately turn off the main power supply to the CWT at Sekem El-Wahat.

2. Seek Professional Help: Do not attempt to fix electrical issues without the guidance of a certified electrician.

8.4 Emergency Contacts

For immediate assistance at the CWT site, the following individuals can be contacted:
- Eng. Mohamed Owis, Manager of Sekem Farm El-Wahat, Mobile: (+20) 100 172 3984
- Mr. Sobhi El-Saadani, Administration Manager, Sekem Farm El-Wahat, Mobile: (+20) 105 004 5719

In case of any technical issue, please contact the following:
- Prof. Wael Khairy, PI of the MED-WET Project, HU, E-mail: wael.khairy@hu.edu.eg, Mobile: (+20) 122 479 8846
- Eng. AyaAllah Yasser, Research Assistant, MED-WET Project, HU, E-mail: aya.yasser@hu.edu.eg, Mobile: (+20) 115 983 3222

8.5 Feedback and Updates

- Continuous Improvement: constructive feedback helps identify areas of improvement, ensuring that the CWT's demonstration site at Sekem El-Wahat remains at the forefront of sustainable agriculture and irrigation water production's cheap and simple technologies.
- User Experience: feedback provides insights into the practical experiences of those operating and maintaining the CWT at Sekem El-Wahat, ensuring that its design and functionality align with the needs of all users including the smallholder farmers as well as the large agricultural scheme investors.
- Safety: feedback can help identify potential safety concerns or areas where clearer instructions may be required, ensuring the safety and well-being of all personnel.
- The CWT's Operation & Maintenance Manual is a dynamic document. Periodic updates will be made to incorporate new technological advancements, address feedback, and ensure that the manual remains relevant and up-to-date.
- Users are encouraged to regularly check for updates and ensure they are working with the latest version of the manual.

9. ACKNOWLEDGEMENTS

The development, realization and operation of the Engineering Constructed Instream Wetland site (CWT-Model I) is the culmination of significant efforts from various teams, institutions, and individuals. We extend our heartfelt gratitude to:

- The HU President, Sekem CEO, senior management officials of HU and the Dean of the Faculty of Engineering for their insightful remarks and advices during the operation of the CWT in Sekem El-Wahat.
- The whole community of Heliopolis University for Sustainable Development (HU) and its dedicated team, for their expertise and continuous efforts in research, design, and implementation of the CWT in Sekem El-Wahat, Egypt.
- The manager, team of technicians, workers and administrators at Sekem Farm El-Wahat El-Bahariya for their unwavering support and collaboration in bringing this CWT installation to such excellent realization.
- The MED-WET Team and The European Union/Prima for providing enlightening remarks, technical advices, the framework, interest and funding for the culmination of the CWT technology under the MED-WET project.
- All research assistants, site engineers, technical persons, agronomists, plumbers, and electricians who contributed their specialized skills to make the CWT a reality.
- The local community and all stakeholders in El-Wahat El-Bahariya who have been involved in the project for their valuable feedback, reflections and cooperation.

9.1 Disclaimers

Equipment Variability: while this manual provides instructions and guidelines for the operation and maintenance of the CWT technology's demonstration site, users should be aware that treatment segments, equipment, components as well as physical, chemical and micro-biological decay processes vary in nature and sizes due to climate and other physical settings of other sites. Always consult specific instructions provided by equipment manufacturers or suppliers.

Liability: the CWT's operation and maintenance works must be carried out under the supervision of qualified personnel. The responsibility for ensuring that all works adhere to local and international safety standards lies with the operator party (HU and Sekem). No third party will be held liable for any damages or injuries resulting from incorrect operation or maintenance of the CWT site.

Dynamic Document: the technical instructions and guidelines for CWT's OM manual are subject to periodic updates to incorporate technological advancements or feedback. End-users are encouraged to ensure that they are referencing the most recent version of the manual.

10. CONCLUSION AND RECOMMENDATIONS

The operation of the Engineering Constructed Instream Wetland site (CWT-Model I) with its low-cost, low-energy, nature-based and efficient technologies is an excellent demonstration site for large farmers, investors as well as smallholder farmers of El-Wahat El-Bahariya

and the surrounding desert communities in El-Farafra, El-Kharga, El-Dakhla and Siwa Oases. In addition, the (CWT-Model I) is considered an added value for the Sekem Farm El-Wahat because it contributes to increasing the water productivity for irrigation and reducing the pollution hazards of the domestic wastewater inside the farm.

Remember always to consult specific instructions provided by equipment manufacturers and suppliers, as these will cater for the unique specifications and requirements of each component.

Throughout the operation process of the Engineering Constructed Instream Wetland (CWT-Model I) site, various other documents have been referenced to provide comprehensive insights, specific instructions, and detailed guidelines. For ease of access and to ensure that all procedures are followed with utmost precision, a list of these referenced documents is provided below.

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