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SUSTAINABLE IMPLEMENTATION OF CONSTRUCTED WETLANDS TECHNOLOGY IN TANZANIA: GUIDING PRINCIPLES ASSOCIATED WITH HEALTH ASPECTS

Anesi S. Mahenge
Ardhi University, School of Environmental Science and Technology,
P.O Box 35176, Dar es Salaam, Tanzania

ABSTRACT

In Tanzania, the need for guiding principles pertaining to health aspects for sustainable implementation constructed wetland technology is of paramount importance because without these guidelines, users of the technology are at risks of getting diseases such as cancer and those related to water. The guidelines will provide to all stakeholders especially implementers of constructed wetland technology with an easy guidance associated with healthy aspects required to be considered during planning, designing, construction, implementation and reuse of constructed wetland effluents so that they will be at minimal risk of getting diseases. The methodologies used were documents review and interview.

Keywords: Constructed Wetland Healthy Aspects, Sustainable Use, Wastewater.

1. INTRODUCTION

Constructed wetlands (CWs) are planned systems, designed and constructed to employ wetland vegetation to assist treatment of wastewater in a more controlled environment than occurring in natural wetlands. Hammer [1] defines CW as a designed, manmade complex of saturated substrate, emergent and submerged vegetation, animal life, and water that simulate natural wetlands for human uses and benefits. CW are "eco-friendly" alternatives for secondary and tertiary treatment of municipal and industrial wastewater. The pollutants removed by CWs include organic materials, suspended solids, nutrients, pathogens, heavy metals and other toxic or hazardous pollutants. Different types of CWs can effectively treat secondary or tertiary treated wastewaters. However, they should not be used to treat raw sewage and, in industrial situations, the wastes may need to be pre-treated so that the biological elements of the CW system can function effectively with the effluent. CW's are practical alternatives to conventional treatment of domestic sewage, industrial and agricultural wastes, storm-water runoff and acid mine drainage [2], [3].

There is not even a single city or town in Tanzania with adequate sewage treatment facilities [4]. Under normal circumstances, urban centres would be served by wastewater treatment plants and regulated septic disposal facilities, while peri urban areas would experience un-regulated waste dumping and burial. In Tanzania however, a very small portion of the urban centres is served with adequate wastewater treatment facilities. Coverage by sewerage services in major cities such as Dar es Salaam, Arusha and Mwanza is less than 15%, with an exception of Moshi at 40%

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[5]. About 60-70% of the urban population [6], in Tanzania, lives in unplanned peri-urban areas, relying mostly on pit latrines and septic tank soak away systems for sanitation. Major problems with pit latrines and septic tanks in Tanzania are leakages caused by poor construction, flooding of low lying areas, and lack of maintenance. Soak away pits fill up due to poor infiltration when built in clay soil areas. Possibility of conventional systems polluting drinking water sources is high due to close proximity to shallow water wells and surface water sources. Additionally, there is generally lack of adequate wastewater treatment due to lack of funds to install centralized wastewater treatment systems and lack of commitment among policy makers to seriously deal with the problem.

To tackle these problems, good solutions for improving sanitation systems in Tanzania have to be identified. A sustainable low cost solution for hygienic sanitation identified is engineered wetland systems, also known as Constructed Wetlands (CW). The use of constructed wetlands for domestic wastewater treatment in Tanzania has gained much popularity over the last fifteen years since the early pioneering works by WSP and CW research project [2], Kimwaga [7], Katima [8], Kaseva [9], Kiwanuka [10], Mwegoha [11], Mbwette [12, 13], Mutamba [14] and Senzia [15].

The long operational experience and research results have shown greater treatment efficiency, greater nutrient reclamation as compared to other natural biological treatment systems. These systems are low energy-consuming and use natural processes, in contrast to the complex conventional treatment systems that are high energy and high-maintenance demanding. Other advantages include: simplicity, low construction, operation, and maintenance costs, use renewable energy, use locally available materials and robustness. Although they have been found to be commonly used for treating domestic wastewaters, they can also be used for treating industrial wastewater, including water that contains agro-industrial wastes.

Another potential advantage of using sub-surface flow constructed wetlands is that they do not allow mosquitoes to breed. Also, the systems can be designed in clay soils by which septic tank systems cannot fit, they can be designed in areas with high water table because the maximum depth below the ground surface is 0.6 m, they can fit for decentralized wastewater treatment as it can be designed in small, medium and large scales. Before the construction of wetlands, it should be borne in mind that health aspects are very important to be considered during the planning phase, design approach, operation and maintenance aspects. This is because a well-designed wetland with health aspects built-in, significantly reduces risk of water related diseases to workers and effluent users, and protects the water receiving bodies.

The overall objective is to provide Policy, Institutional and Legal guidelines in order to increase access, affordability, and sustainability of constructed wetland technology in urban, peri-urban and rural area of Tanzania. The specific objectives are to provide health aspects requirements in planning, designing, construction and implementation phases of constructed wetlands.

2. METHODOLOGY

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The methodologies used were documents review and interview. Relevant research reports on constructed wetland technologies in Tanzania were reviewed. Different researchers who researched on constructed wetland technologies in Tanzania were interviewed

HEALTH ASPECTS IN PLANNING, DESIGNING, CONSTRUCTION AND IMPLEMENTATION OF CONSTRUCTED WETLANDS TECHNOLOGY

This section demonstrates in details the aspects of health considered in the planning, designing, construction, implementation and monitoring phases of constructed wetlands technology, the stakeholders vulnerability to health risks have been identified and measures to reduce or control health risk have been proposed. Although health aspects have been considered in each phase, more weight has been given to effluent reuse. Most of the control measures provided are based on the WHO guidelines for safe use of wastewater for agriculture and aquaculture.

Planning phase

Health is of central importance in the planning of constructed wetlands to ensure proper implementation of the technology and good health to users and implementers of the technology. In the planning phase, much information is needed to be collected such as

i. Hygiene and Sanitation service of the area
ii. Reported cases of common locally water related diseases
iii. Climatic condition (i.e. temperature, rainfall, seasons, etc)
iv. Socio-economic activities
v. the economic status of the community
vi. Land availability - proposed site for final effluent discharge/reuse
vii. Quantity and quality of source wastewater (influent and effluents)
viii. Intended/final use of treated effluents (it can be for agriculture or aquaculture)
ix. Irrigation practice
x. Type of Crops

Design Phase

The design of a constructed wetland is dependent upon the volume and concentration of the incoming wastewater. The designers should take into consideration the determination of the various pollutants especially pathogens and heavy metals in determining the size and type of constructed wetland. Pathogens and heavy metals in wastewater pose health risks to human, therefore, constructed wetlands if well designed and constructed can protect the public from these risks. Pathogens cause water related diseases while heavy metals cause cancer. The following are considerations given during designing stage to optimize pathogens and heavy metals removal

i. Designers must have accurate information on the volume and characteristics of wastewater including microbiological and chemical characteristics of the wastewater.
ii. Designers should optimize the mechanisms of pathogens and heavy metals removal such as sedimentation, filtration, absorption of biomass

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iii. Health aspects in a design phase are essential especially when the final effluent is planned to be reused either for irrigation or aquaculture. In case the final effluent is planned to be reused in irrigation or aquaculture, the design approach should be focused on minimizing the pathogens, heavy metals and optimizing the nutrients for crops and fish (Figure 1).

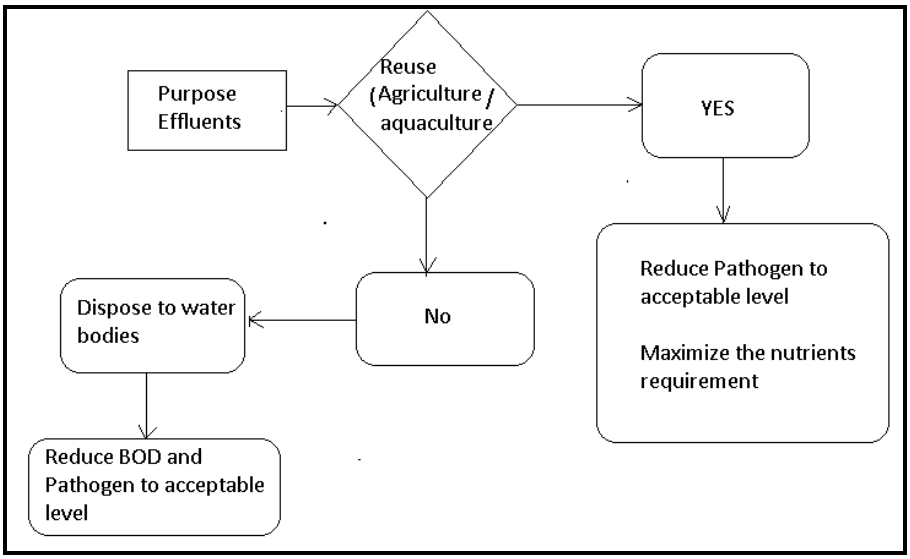

Figure 1: Algorithm of design approach which considering the Health aspect for CW

Construction Phase

During the construction phase, the contractor shall keep the work area clean and free from debris and trash, specifically the walking and working surfaces. Tools, materials, dirt, paper, etc. should be promptly cleared and disposed of by the Contractor. Borrow pits should be filled, and surfaces kept even so that mosquitoes are not given breeding sites.

Implementation Phase

Wastewater which has been treated by a properly designed and constructed subsurface flow constructed wetlands generally meets the discharge standards with respect to pathogens and heavy metals levels and therefore they do not need further treatment. If the wetlands are not properly operated and maintained, they may pose health risks to users of the technology and therefore for safety reasons and depending on the intended reuse of the effluents, a tertiary treatment of wastewater is necessary.

The following should be done during the operation and maintenance of the CW

i. Plant operators should use health protective gears to reduce risk of diseases caused by agents present in the wastewater, sludge and in pretreatment

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ii. Protective gears should be put on during uprooting or pruning unwanted plants and/or leaves, since the operators may be exposed to risks such as wild animals, fallen broken or sharp objects.
iii. To ensure that surrounding residents do not come in contact with the sludge/wastewater in the treatment facility, fencing of the facility is necessary.
iv. The inclusion of specific safe access to outlet points is necessary feature to enhance health and safety for monitoring personnel. Specific attention must be given to deeper ponds by the placement of warning signs and life buoys as appropriate.
v. Settled wastewater in the pre-treatment facility pose high health risks therefore caution should be taken during inspections and emptying to decrease the risks.
vi. Sludge in most cases contains pathogens, therefore, it must be properly treated, for example in drying beds or composting facilities before being given to farmers for application

Reuse of the Constructed Wetland effluents for Irrigation

The main reason to consider health aspects in the reuse of constructed wetland effluents is to prevent community members from getting diseases such as water related diseases, cancer. Groups/categories of people who are at health risks associated with reuse of constructed wetland effluents in agriculture include: agricultural workers and their families, crop handlers, consumers of crops and those living near the areas irrigated with wastewater. For minimization of health risks associated with reuse of effluents, it is essential to use appropriate control measures for each corresponding group [16].

For protection of agricultural field workers and crop handlers the following are requisite.

i. Appropriate irrigation practice
ii. Provision of protective gears such as gloves, clothing, boots,
iii. Maintenance of good hygiene
iv. Immunization against infectious diseases

For risk reduction purposes to consumers who consume crops irrigated by constructed wetlands effluents, the following are requisite

i. Irrigated crops contaminated by pathogens should be restricted to tree crops and/or to those which are cooked before eating such as maize and rice, or,
ii. For minimization of contamination due to pathogens, crops can be grown on raised beds with furrow irrigation, so that the polluted water does not come in direct contact with the leaves.
iii. Agricultural and aquaculture products contaminated by pathogens should be cooked before consumption.
iv. In case of presence of higher levels of heavy metals (above recommended standards), agricultural and aquaculture products should avoided for human consumption.
v. Although there is no evidence to suggest that those living near wastewater-irrigated fields are at significant risk, irrigation using sprinklers should not be used within 100m of houses or roads.

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vi. Special care must always be taken in wastewater management schemes to ensure that agricultural workers and the public do not use wastewater for drinking or domestic purposes accidentally or due to lack of an alternative. All wastewater channels, pipes and outlets must be clearly marked and preferably painted a special colour.

Reuse of the constructed wetland effluents for Aquaculture

The quality of water to be used in aquaculture is important to be known, because if quality is not reached, it may cause pollution to fishes grown in if. Transmission of pathogens can occur through people who handle contaminated fish [16]. The measures which can be taken to protect human health when constructed wetland effluents are used for aquaculture are similar to those taken when wastewater is used for agriculture which may include; treatment of wastewater to an acceptable level and protection of aquaculture workers and fish processors.

Protection of aquaculture workers and fish processors should include:

i. Use of protective gears such as gloves
ii. Personal flotation devices should be available for immediate use when needed.
iii. Hygienic cleaning of the fish.
iv. Thoroughly washing of hands with soap immediately after harvesting and cleaning fish.
v. Fish should be properly cooked.

MONITORING PHASE

Heavy metals, nutrients, trace metals and pathogens are sensitive parameters to be monitored in wastewater that is used for irrigation and aquaculture and be monitored in irrigated crops and aquaculture products.

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