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CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH

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PREFACE

There is a growing concern on the adverse impacts of climate on biodiversity. This phenomenon is greatly manifested in form of shifting weather patterns threatening global food security, health and species existence. Humanity is at the receiving end of the consequences of climate change hence there is a need to step up actions on all fronts- overtime, everywhere all at once.

This calls for collaboration, partnership and networking to strengthening synergy among relevant stakeholders in a bid to tackling climate change menace. This forms the basis for the theme of this year world Environmental conservation conference: **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH.** The theme is conceived with a view to create an interface for information sharing and offer opportunities for participants to refine their commitments and pledges in the quest to achieving Sustainability in the face of climate change.

This year World Environmental Conservation Conference is memorable in the sense that it received overwhelming funding from the host - West African Science Service on Climate Change and Adapted Land use). WASCAL is posed to provide information and knowledge at the local, national and regional level to cope with the adverse impacts of climate change. Thus, this conference will offer opportunities for participants to learn from good practices demonstrated and showcase by WASCAL during the course of the conference. It will also strengthen staff-student exchange and provide prospect for Doctorate Research Doctoral Research in West Africa Climate System Programme (DRP WACS) – WASCAL among others.

Special appreciation goes to the management of The Federal University of Technology, Akure the host institution, National Park Service and African Regional Center for Space Science and Technology Education-English (ARCSSTE-E) that co-host this conference. We equally acknowledge other private, individual and corporate organizations that have contributed towards the success recorded in this event.

All the submitted articles were subjected to strict double blind peer-review process by the reviewers that are experts in the area of the particular submitted manuscript. The accepted manuscripts are published in WECC 2023 proceedings and also available for download on the organization website (www.necorng.org).

The accepted manuscripts fall within the underlisted subthemes:

- Climate change adaptation strategies in Agriculture, Forestry and Other Land Use (AFOLU)
- Climate smart city and architectural landscape design
- Retrofitting and decarbonization in tourism and hospitality industry
- Indigenous knowledge and local innovation in climate change adaptation
- Climate risk management, health, safety and hygiene
- Carbon credit-offset marketing/circular economy
- ICT development in environmental conservation (image processing and acquisition, computer vision, graphics, speed, interface technology, HMD devices, GIS: Body Tracking, AI and IOT, VRT, IVE).

We commend our keynote speaker Prof. Douda Kone Director Capacity Building Department, WASCAL Headquarter, Ghana and other guest speakers Prof. Babatunde Rabiu, Director General, Chief Executive Office, African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E) and Dr. Goni I. M., Conservator General National Park Service.

It is hoped that researchers, students and policy makers will find the papers in this book very useful. Even though all the papers were reviewed and edited, the content and option expressed remain essentially that of the authors and not necessarily that of Netlink Environmental Conservation Organization.

Dr. Oladeji S. O.

President Netlink Environmental Conservation Organization

Convener World Environmental Conservation Conference

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PERFORMANCE EFFICIENCY OF CONSTRUCTED WETLAND (CW) PLANTED WITH COMMON REED (*Phragmites australis*) IN THE TREATMENT OF GREYWATERIN AKURE, NIGERIA

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ABSTRACT
Scarcity of freshwater is becoming an increasing problem worldwide especially in the arid and semi-arid regions of the world, hence the need for the treatment of household greywater to augment scarcity. The study was conducted to investigate the performance efficiency of Constructed Wetland (CW) planted with common reed in the treatment of greywater in Akure, Nigeria. Raw greywater was collected from Jadesola female hostel, Federal University of Technology, Akure and pre-treated via a 500 litres sedimentation tank containing different layers of gravel and fine sand and was released into a Vertical Flow Sub-surface Constructed Wetland (CW) planted with common reed (Phragmitesaustralis). The raw and treated greywater were analyzed for BOD, COD, TDS, and heavy metals. The results showed that the CW was effective in reducing chemical parameters analyzed Following treatment, the greywaterbecame suitable for irrigation purposes because values of the chemical parameters were reduced enough to meet the requirement (standards) for wastewater reuse as irrigation in agriculture and outdoor needs. Constructed Wetland was effective in the treatment of greywatergoing by the reduction in BOD by 91.4%, COD by 91.5% and TDS by 38.7%. Findings from this research is useful waste water treatment (recycling and reuse) for irrigation in agriculture and importantly in efforts to address scarcity of freshwater in an era of climate change.

Keywords: *Greywater, Common reed, Irrigation, Constructed wetland, wastewater recycling, agriculture*.

INTRODUCTION

Due to ever increasing population, enormous volume of domestic wastewater is being produced in cities. Indiscriminate discarding of such water is a source for pollution of air, soil and groundwater supplies. A rivalry for freshwater among different water-use sectors already exists in several arid and semi-arid regions, causing a decreased allocation of freshwater to agriculture. For this reason, dwindling supplies ofgood quality water for irrigation and increasing demand for other users is placing increasing pressure on non-conventional water resources [1]. Among these various water conservation practices, the use of Treated Wastewater (TWW) has taken on greater significance. Indeed, this quality of water for agriculture offers the greatest scope for application because it usually has the potential to meet growing water demands, conserve potable supplies, reduce disposal of pollution effluent into surface water bodies, allow lower treatment costs and enhance the economic benefits for growers due to reduced application rates for fertilizer [2, 3]. Greywater is all wastewater that is discharged from a house, excluding blackwater (toilet water). This includes water from showers, bathtubs, sinks, kitchen, dishwashers, laundry tubs, and washing machines. It commonly contains soap, shampoo, toothpaste, food scraps, cooking oils, detergents and hair. Greywater makes up the largest proportion of the total wastewater flow from households in terms of volume. Typically, 50-80% of the household wastewater is greywater. If a composting toilet is also used, then 100% of the household wastewater is greywater. Greywater is a reflection of the household activities and its characteristics are strongly dependent on living standards, social and cultural habits, number of household members and the use of household chemicals. Greywaterfrom bathtubs, showers and hand-wash basins is considered as the least polluted greywater source. The average greywater contribution to the total organic load (BOD_5) amounts to about 40 – 50%. Greywater also contributes to one fourth of the total suspended solids and up to two thirds of the total phosphorous load. Dish washing and laundry detergents are the main sources of phosphorous in greywater. In countries where phosphorous-free detergents are used, these loads are minimal. Kitchen greywater is the main source of nitrogen in domestic greywater, while the lowest levels are generally observed in bathroom and laundry greywater. The use of greywater for irrigation purposes is becoming widespread due to prevailing water scarcity challenges and population growth [4]. The treated greywater can be supplied for irrigation of indoor plants as the greywater is most suitable for this purpose. However this application must meet the stringent requirements from possible exposures to greywater. Treated greywater can also be used for irrigating agricultural crops and turfs and for maintaining decorative fountains or landscape impoundments. Agricultural irrigation using greywater to support crop production is a well-established practice in arid and semi-arid regions.

Constructed Wetlands are engineered systems designed to utilize natural processes for water quality improvements. They perform this function by removing contaminants in wastewaters through a mixture of physical (filtration, sedimentation), biological (microbial processes, plant uptake) and chemical (precipitation, adsorption) mechanisms [5]. They typically have watertight clay or synthetic liners, and engineered structures to control the flow direction, liquid detention time and water level. Depending on the type of system, they may or may not contain inert porous media such as rock, gravel or sand. In constructed wetlands, vegetation plays a partial role during the treatment process, because it helps in supplying oxygen to the microorganisms in the rhizosphere, reduce the amount of nutrients in the system by uptake and perhaps provide more surface area in the rhizosphere for the microorganisms [6]. Generally, constructed wetlands are designed to maximize the physical, chemical and biological abilities of natural wetland to reduce the biochemical oxygen demand (BOD), total suspended solid (TSS), total nitrogen (TN), phosphorus and pathogen as wastewater flows slowly through the vegetated surface [7, 8]. Constructed wetlands are classified as either *Free Water Surface (FWS)* systems or *Subsurface Flow (SSF)* systems. Any wetland, in which the surface of the water flowing through the system is open to the atmosphere, is classified as an FWS system. In SSF systems water is designed to flow through a coarse media, without coming into contact with the atmosphere. Free water surface wetlands can be sub-classified according to type of vegetation: Emergent macrophyte, free floating macrophyte, or submerged macrophyte. Subsurface flow wetlands (which by definition must be planted with emergent macrophytes) can best be sub-classified according to their flow patterns: Horizontal flow or Vertical flow. *Phragmitesaustralis* is one of the most widely distributed wetland plant worldwide. It is a highly productive grass (*Poaceae*) with an above-ground net primary production ranging from less than 3 t ha^{-1} y^{-1} to as much as 30 t ha^{-1} y^{-1} [9] *Phragmitesaustralis* can be found all over the world except in Antarctica, but its core distribution area is Europe, the Middle East and America [10]. Characteristic of wet sitesmost often range from those with water level slightly below the soil surface to one metre above ground level [11, 12, 13] and grows mostly at the shores of lakes and gulfs, along riverbanks and on nutrient-rich peatlands.Thus, despite the widespread use of constructed wetland in wastewater treatment, research on its effectiveness in the treatment of greywater is still relatively scarce in Nigeria. Therefore, the purpose of this research is to evaluate the performance efficiency of constructed wetland planted with common reed in the treatment of greywater.

METHODOLOGY

The study was carried out within the premises of JadesolaFemale Hostel, Federal University of Technology, Akure (FUTA), Nigeria. FUTA is located within the rainforest zone of Nigeria on latitude 7.3043^{0}N; longitude 5.1370^{0}E and lies within the tropical humid climate with two distinct seasons. Influent greywater was sourced from the university's female hostel of about 200 occupants. Water from baths, showers, kitchen and bathrooms were drained through pipes of diameter 128 mm to an underground 500 litres water reservoir that served as a holding/sedimentation tank for greywater. During the experiment, pretreatment took place in a 500 litres cylindrical container, where food particles and other suspended solids (hair and Lint) were filtered through a media of gravels (diameters < 32 mm, 24 mm, and 16 mm) and a final layer of fine sand (diameter 0.2 mm) accordingly. The process began with PVC pipes from the hostel entering a collection/sedimentation tank that filter out suspended solids (also settling BOD, heavy metals, and other nutrients). The filtered greywater was released into the underground constructed wetland (CW) vertically through pipe by gravity. The CW is a plastic container of surface diameter 1.5 m and depth 0.6 m. It also consisted of filters as in the sedimentation tank with common reed planted on it. Water is purified by reedbeds when whole reed stalks initiate bacterial activity by conveying air (i.e. oxygen) to the roots *via* the aerenchyma]. The retention time of the filtered greywater in the CW was calculated to be 2 days before collecting for analysis. Water samples were collected from raw greywater and treated greywater. These were collected in 1 litre polythene bottles from the study area and analyzed. The used polyethylene bottles had been pre-washed with acid and distilled water and then were dried. The parameters determined were physical parameters such as pH, chemical parameters such as: Biochemical Oxygen Demand (BOD), Total Nitrogen (TN), Chemical Oxygen Demand (COD), Electrical conductivity (EC) and Total Dissolved Solid (TDS), The pH and EC were determined immediately after collection in situ by pH meter and EC meter respectively [15], while Heavy metals like Ni, Cd, Zn, Cu, and Pb were tested by the Chemistry and Analytical Laboratory of the university. Biochemical Oxygen Demand (BOD_5) indicates the amount of water dissolved oxygen consumed by microbes incubated in darkness for five days at an ambient temperature of 20°C, while Chemical Oxygen Demand (COD) was determined in the laboratory by the standard Open Method in a few hours.

RESULTS AND DISCUSSION

Performance of the Constructed Wetland

The constructed wetland was planted with common reed for the treatment of greywater and results showed that differences in pollutants removal efficiencies. The efficiency in reduction of Biochemical Oxygen Demand (BOD) is 90.92%, for Chemical Oxygen Demand (COD) is 91.46%, for Total Dissolve Solid (TDS) is 38.73% and for Nitrogen, the removal efficiency is 47.01% (Table 1). These values conformed with the findings from Patel *et al.* (2022) [16] who reported 87.5 and 70% removal efficiencies for BOD and COD respectively, using electrocoagulation treatment process in the treatment of greywater. The results of the present study are also in agreement with Ridderstolpe [17], who reported 90 – 99% removal efficiencies for both BOD and COD, and 30% nitrogen removal for vertical subsurface flow. Previous report by Deguenonet al. [18] also showed that COD and BOD have removal efficiencies of 93% and 92% respectively when common reed was used to treat a campus domestic sewage. Similar results was obtained by Marzecet al. [19] wheremore than 95% of BOD and COD were removed in the tested hybrid CW system planted with common reed. Thus, the wetland planted with common reed was very effective because it was able to remove large amounts of pollutants from the water.

Table 1: Effects of constructed wetland on chemical constituents of greywater

Parameter	Raw Greywater	Treated Greywater	Removal efficiency (%)
BOD (mg/l)	286.40	26.00	90.92
COD (mg/l)	415.77	35.51	91.46
TSS (mg/l)	107.00	92.00	14.02
NO_3 (mg/l)	23.40	12.40	47.01
SO_4 (mg/l)	2551.30	1563.70	38.71
Na (ppm)	60.30	42.40	29.68
K (ppm)	28.60	7.50	73.78
TDS (mg/l)	2001.00	1226.00	38.73
EC (dS/m)	4.02	2.26	43.78

Nutrients

From the results obtained (Table 1), treated greywater contained appreciable concentration of nutrients essential for plant growth such as nitrogen (N), potassium (K) and phosphorus (P). Therefore, using treated greywater will reduce usage of chemical fertilizers that contribute to various environmental hazards.

Heavy metals

Heavy metals included cadmium, copper, lead, zinc, nickel, and manganese [20]. Table 2 shows that heavy metals concentrations in treated greywater are in the WHO acceptable limits so they may not affect soil and crop. Some heavy metals are essential to plant growth at low concentrations. Nevertheless, these heavy metals become toxic and harmful at high concentrations.

Table 2: Effects of constructed wetland on the concentrations of heavy metals of greywater

Element	Raw greywater	Treated Greywater	WHO limits, 1989[21]
Cd (ppm)	Nill	Nill	0.003
Cu (ppm)	0.120	0.030	2.000
Fe (ppm)	0.014	0.002	0.300
Mn (ppm)	0.105	0.021	0.400
Ni (ppm)	0.002	Nill	0.020
Pb (ppm)	0.050	0.001	0.010
Zn (ppm)	0.173	0.156	3.000

CONCLUSIONS

This research evaluated the performance efficiency of constructed wetland planted with common reed in the treatment of greywater in Akure, Nigeria. The results showed that the constructed wetland (CW) was effective in the treatment of greywater. Following treatment, the reductions in BOD, Cod and TDS were 91.4, 91.5 and 38.7 % respectively. It is concluded that inclusion of common reed with CW, improves its performance efficiency. It is thereby recommended that more research can still be carried out using effluents from treated greywater for irrigationand evaluation of other grass species for efficiency enhancement of CW.

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