Viability Study for a Pilot Project for the Reuse of Treated Wastewater for Irrigation in Agriculture in the University of the West Indies, St. Augustine Campus, Field Station (UFS)

Trinidad and Tobago

Financed by

Co-implemented by

Co-executed by

The Viability Study for a Pilot Project for the Reuse of Treated Wastewater for Irrigation in Agriculture in the University of the West Indies, St. Augustine Campus, Field Station (UFS) was spearheaded by the Ministry of Public Utilities Department (MPU) and financed by The Global Environment Facility (GEF) under the GEF CReW+ Project.

The GEF CReW+ is a partnership project funded by the Global Environment Facility (GEF) that is being co-implemented by the Inter-American Development Bank (IDB) and the United Nations Environment Programme (UNEP) in 18 countries of the Wider Caribbean Region (WCR).

This project builds upon its previous successful phase "The Caribbean Regional Fund for Wastewater Management (CReW)" project (2011-2017). CReW+ is being executed by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, the Organisation of the American States (OAS) and the Secretariat of the Cartagena Convention (CAR/RCU) on behalf of the IDB and UNEP respectively.

The 18 participating CReW+ countries (Barbados, Belize, Colombia, Costa Rica, Cuba, Dominican Republic, Grenada, Guatemala, Guyana, Honduras, Jamaica, Mexico, Panama, Saint Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago) vary geographically from large, continental countries to small island states, with significantly different political, linguistic and cultural contexts.

About the GEF: The Global Environment Facility (GEF) has provided $22 million in grants and blended finance and mobilised nearly $120 billion in co-financing for more than 5,200 projects and programmes. The GEF is the largest trust fund focused on enabling developing countries to invest in nature and supports the implementation of international conventions on biodiversity, climate change, chemicals and desertification. It brings together 184 governments, plus civil society, international organisations, the private sector and partners.

Published by:	*GEF CReW+ Project* *Implementing solutions for an integrated water and wastewater management for a clean and healthy Caribbean*
Authors:	*Ronald Roopnarine (University of the West Indies)* *Christoph Platzer (AKUT)* *Carolina Cabral (AKUT)*
Design:	*GEF CReW+ Project*
Date:	*May 2023*
Commissioned by:	*Inter-Agency Coordination Group (IACG)*

www.gefcrew.org

Content

1. Introduction

Water reuse is not yet a widely used, regulated source for potable or non-potable water supply, particularly in the Caribbean region. However, while it may not exist in a formalized or regulated setting, prior to the development of public water supply systems, water reuse was a common practice for domestic and agricultural applications (Peters, 2015). Within Trinidad and Tobago, unregulated water reuse occurs in some areas as a source for irrigation for agriculture. This is most prominent in the Caroni and Maloney districts where farmers use river water downstream of wastewater treatment plants. This is often linked to water supply deficits, especially during the Dry Season (January – May annually). It should be noted that this practice is prohibited according to present laws, unless approval is granted by the Water and Sewerage Authority (WASA), however, in many instances abstraction occurs without the necessary permits as enforcement is limited. Warrick and Ekwue (2014) identified the dry season deficits as a major setback in the agricultural sector and noted that adequate supply of water dedicated to irrigation was crucial in order to realize high productivity and an internationally competitive agricultural sector. Currently, the majority of agricultural production is rain-fed, which limits year-round productivity. According to a Ministry of Environment Report (WRA, 2001), projected consumer water demand can be categorized into four (4) distinct categories viz. domestic (42%), industrial 26%, irrigated agriculture (3%) and unaccounted (29%) by 2025. The report also predicted that the agriculture sector's allocation may be limited moving forward, since it was unlikely to expand given the competing development of the other economic sectors. Projection by the Ministry of Agriculture Land and Marine Resources (MALMR, 2007) highlighted that there was a substantial amount of irrigable land, which could be developed once irrigation water was made available. This could take the irrigation demand up to 48% by 2025. This demand cannot be satisfied based on current water sources and operational procedures, which will undoubtedly stymie any further development of the agricultural sector. Consequently, Warrick and Ekwue (2014) identified wastewater reuse as a possible solution to the potential water supply deficit.

As part of the Global Environment Facility Caribbean Regional Fund for Wastewater Management (GEF CReW+) project, Trinidad and Tobago has completed an assessment study for wastewater reuse as well as developed a voluntary national standard (TTS 664:2022). In the next phase a pilot project will be implemented.

Undertaking these pilot projects will be effective in assessing the viability and effectiveness of using treated wastewater for irrigation in a controlled and monitored setting that allows for rigorous testing of the water quality, including the presence of contaminants and the impact on crop growth and yield. An assessment of the feasibility particularly in terms of health risks and addressing any concerns or challenges that arise, pilot projects have the potential to instil confidence in farmers, consumers, and regulatory bodies regarding the safety and efficacy of using treated wastewater in agriculture. Building trust through these pilot projects is crucial for wider acceptance and adoption of wastewater reuse practices in Trinidad and Tobago, as it provides a solid foundation for future large-scale implementations, promotes sustainable water management, and ensures the long-term viability of agricultural practices.

In lieu of this, a wastewater reuse pilot /demonstration site is important in assessing the feasibility of using treated wastewater from a centralised wastewater treatment plant (WWTP) for agricultural purposes. Consequently, this study aims to examine and address the requirements and conditions for conducting the pilot study in the subsequent phase.

2. Objective

The main objective of this study is to evaluate the conditions necessary for the pilot study that aims to evaluate the use of treated wastewater for agricultural purposes.

The specific objectives are:

1. To determine the necessary area for each crop.
2. To analyse the quantity and quality of treated wastewater required for the pilot study.
3. To determine the necessary measurements to compare the use of treated wastewater and conventionally sourced water
4. , e.g., growth and development, yield and quality of selected vegetables grown with wastewater and conventionally sourced water (control).
5. To determine how to assess soil health and quality after application of treated wastewater.
6. To estimate the costs of the pilot study.

3. Experimental Layout and Design

Proposed Pilot Site

After discussing possible sites for the pilot, it was decided that the research will be conducted at the University of the West Indies, St. Augustine Campus, Field Station (UFS) in the area designated for insect farming. The UFS provides a semi-controlled environment with uniform soil type and allows for experimental assessments , where produce will not be allowed to enter the market prior to ensuring there are no health risks. This field site is also installation ready and baseline information on soil properties exists, which eliminates cost associated with land preparation and soil assessment. Both wastewater and conventionally sourced water will be transported and stored in tanks at the production site.

Proposed Crops

Three crops (Lettuce, tomato, and beetroot) and two levels of irrigation water (municipal wastewater and conventionally sourced water) will be included with replicates.

The three crops have been chosen as they represent three typical crops in T&T of which two of them (Lettuces and tomato) are very sensitive to quality issues with the irrigation water, as the crops are eaten uncooked. Another reason for the selection is the growth velocity, as the total available timeline is just 12 weeks. In order to demonstrate the quality of the treated wastewater commonly used, surface water serves as the reference for comparison. This is particularly important as irrigation water is currently sourced directly from rivers and streams where quality is often a concern. .

The experimental treatment combinations are as follows:

1. Lettuce irrigated with treated wastewater (LW)
2. Lettuce irrigated with conventionally sourced water (LC)
3. Tomato irrigated with treated wastewater (TW)
4. Tomato irrigated with conventionally sourced water (TC)
5. Beetroot/Sweet Potato irrigated with treated wastewater (BW)
6. Beetroot/Sweet Potato irrigated with conventionally sourced water (BC)

These crops were chosen as they are reflective of the crops that can be irrigated with the various classes of treated wastewater on the standard, TTS 664:2022. The location of the pilot can be visualized in the Figure 1 bellow. The area highlighted in green will be used for the pilot.

Figure 1 - Location of the pilot area

The new Trincity WWTP is the closest WWTP to the UWI field station (pilot site) and the distance between them is shown in ***Figure 2*** below.

Figure 2 - Distance between the WWTP and the pilot location

Vegetable Production and Plot Sizes

1. **Lettuce (*Lactuca sativa*)** - A popular leafy vegetable belonging to the Asteraceae family. It is generally eaten fresh and commonly served as a base of green salads. The production time for lettuce is approximately 6 weeks in field conditions. There will be six plots with lettuce (three irrigated with wastewater and three irrigated with conventionally sourced water). Lettuce seedlings will be planted at a spacing of 0.45 m between rows and 0.30 m within rows. Each replicated plot should have at least 24 plants. Each plot with lettuce will be 3.24 m^2. Therefore, a total of 19.44 m^2 (209 ft^2) (not including space between plots) will be required for lettuce production.
2. **Tomato (*Solanum lycopersicum*)** - A popular fruit vegetable belonging to the

Solanaceae family. Tomatoes **are** eaten fresh, cooked, or processed into value added products. A determinate type will be used in this experiment which will produce fruits for harvesting between 12 to 16 weeks after planting. There will be six plots with tomato (three irrigated with wastewater and three irrigated with conventionally sourced water). Tomato seedlings will be planted at a spacing of 0.9 m between rows and 0.30 m within rows. Each replicated plot should have at least 24 plants. Each plot with lettuce will be 6.48 m^2. Therefore, a total of 38.88 m^2 (418 ft^2) (not including space between plots) will be required for tomato production.

3. ***Beetroot (Beta vulgaris)*** – A root vegetable belonging to the Amaranthaceae family. Beetroot may be used in fresh salads and juices or may be cooked before eating. It is normally ready for harvest between 75 to 90 days after sowing. There will be six plots with beetroot (three irrigated with wastewater and three irrigated with conventionally sourced water). Beetroot seeds will be sown in rows spaced 0.45 m apart. After germination seedlings will be thinned to give a spacing of 0.10 m between plants within a row. Each replicated plot should have at least 24 plants. Each plot with beetroot will be 3.24 m^2 (35 ft^2). Therefore, a total of 6.48 m^2 (not including space between plots) will be required for beetroot production.

Total Production Area

The total production area for all three vegetables is 64.8 m^2 (698 ft^2). For logistical purposes and convenience, the water treatment will be kept in separate locations. Therefore, 32.4 m^2 (349.0 ft^2) will be designated for the treated wastewater trials and 32.4 m^2 (349.0 ft^2) will be designated for conventionally sourced water trials.

4. Water and Quality Requirements

Water requirements and scheduling

The water requirements for the pilot study were estimated as follows.

Approximate Net Rooting Depth (Loamy Soil) = 40mm

Application Efficiency (Drip irrigation) = 90%

*Gross Irrigation Depth = (100*40)/90 = 45mm*

Estimated Irrigation Water Needs for all crops = 10 mm per day (1.16 litre/sec.hectare)

Estimated Application rate: Flow rate of high flow T-tape drip irrigation ribbon with 8-inch emitter spacing at 10 pounds per square inch (psi) = .74 gallons/ minute/100 feet

Estimate total for a 10mm irrigation depth = 0.3 gallons per square feet.

*0.3*700ft*^{2} = ***210 gallons per day (1500 gallons per week).***

The above calculation is an overestimate; however, it will ensure that even in the dry season production can continue.

That means that one treated wastewater truck per week would be sufficient, but two trips per week can be conducted if such is required when implementing the pilot.

Analysis of the necessary treated wastewater quality

The treated wastewater will be assessed upon each delivery to determine compliance with TTS 664:2022 (TTBS, 2022). The treated wastewater will be stored for a maximum period of three days prior to the irrigation.

However, it is important to mention that an initial analysis was performed by the consultants of the current treated wastewater quality data (Table 1 and Annex 1) and it was detected that the coliforms are above the limit in four subsequential analysis (highlighted in yellow).

Table 1 - Trincity New WWTP effluent quality data

Date	pH 6.0 - 9.0	Faecal Coliform C.F.U. /100mL Ref. 400	Total Suspended Solids (mg/L) Ref. 50	Dissolved Oxygen (mg/L) Ref. >4.0	BOD5 (mg/L) Ref. 30	Ammoniacal Nitrogen (as NH3-N) (mg/L) Ref. 10	Total Phosphorus (as P) (mg/L) Ref. 5
21-Nov-22	7.6	220	1	6	2	-	-
16-Dec-22	7.8	1500	2	4	-	-	1.9
20-Jan-23	7.6	45000	6	3	13	8	3.7
02-Feb-23	7.7	6300	8	4	-	6	3.7
15-Mar-23	7.4	13000	26	4	10	-	-
03-Apr-23	7.6	240	7	6	6	-	-

Source: WATER AND SEWERAGE AUTHORITY (WASA), 2023

WASA indicated that the Ultraviolet (UV) disinfection system is not being cleaned regularly and does not have an automatic wiping system. With manual cleaning, the faecal coliforms met compliance in the last sampling done in April 2023. Consequently, it is important to ensure that the system is cleaned regularly during the execution of the pilot. Based on the proposed study period WASA has 6 months to rectify this issue.

This directly affects the possibility of using the water for irrigation of the pilot.

The treated wastewater at the testing field is stored for a maximum of 3 days.

5. Measurements

Table 2 outlines the variables to be measured, description of variables and frequency of data collection.

Table 2 - Variables, description, and frequency of testing

Variables	Description	Frequency of testing	Estimated Cost (USD)
Pre-Testing- Treated Wastewater **Coliform** **Helminth** **BOD/COD** **Turbidity** **Lead** **Cadmium** **Chromium**		**Upon each delivery of treated wastewater (estimated to be weekly)**	**2500**
Plant Growth			
1. Plant height and number of leaves (in case of lettuce)	The height of plants from ground to highest point	Weekly	400 (all samples)

Variables	Description	Frequency of testing	Estimated Cost (USD)
2. Biomass accumulation	Destructive sampling measuring the fresh weight and dry matter of plant organs.	Shortly after planting, midway crop life cycle and at harvesting	300 (all samples)
3. Chlorophyll index	A non-destructive way of analyzing plant health on a regular basis.	Weekly	100 (all samples)
Microbial Quality			
4. Fecal coliform 5. Total coliform 6. Escherichia coli 7. Salmonella 8. Listeria		After harvesting.	2,500 (all samples)
Chemicals and Heavy Metals			
9. Iron (Fe) 10. Lead (Pb) 11. Cadmium (Cd) 12. Chromium (Cr) 13. Manganese (Mn)		After harvesting.	1,500 (all samples)
Physicochemical Analysis			
14. Colour 15. Firmness 16. Sugar 17. Sensory analysis		After harvesting.	500 (all samples)
Soil Analysis (Chemical)			
18. EC 19. pH 20. SOC 21. Microbial Respiration 22. P **23.** K		Before and after	1000 (all samples)
Estimated Total Cost			8,800

Sample Sizes and Data Collection

For all plant growth variables, at least three plants per replicated treatment plot will be used at each sampling time. For microbial quality assessment, and chemical and heavy metal analysis for a composite sample of three plants from each replicated plot will be prepared giving a total of three data points for each treatment. For physicochemical analysis of at least three plants per replicated treatment plot will be used after harvesting. Physicochemical analysis especially sensory analysis will only be performed if the vegetables are deemed safe after microbial and chemical and heavy metal analysis.

6. Time Schedule and costs

The Table 3 bellow presents the estimated time, costs, and responsibilities for each activity of the pilot project implementation.

Table 3 – Implementation plan with costs estimation for the pilot

Activity	Month	Duration	Responsibility	Cost (USD)	Funding source
Site Preparation	1	2 weeks	UWI	500 to 1,000	CReW+
Procurement of Irrigation and storage equipment inclusive of the following: - Drip irrigation Kit (Drip tape, Mainline, Filter, regulator, couplings, clamps, goof plugs, pumps etc.) - Storage Tanks -	1	1 month	MPU	8,000	CReW+

Activity	Month	Duration	Responsibility	Cost (USD)	Funding source
Minimum 3- 1000 Gallon tanks. Note: These are subject to the type of irrigation method being utilised					
Setting up irrigation equipment	2	2 weeks	UWI	2,000	CReW+
Planting and Maintenance of Crop plots	2	12 weeks	UWI	2,000	CReW+
Transportation of the treated wastewater from the new Trincity WWTP to UWI field station	2 to 4	12 weeks (twice a week)	MPU/WASA	6,000 (Quotation in Annex 2)	CReW+
Sampling and Testing	2	12 weeks	UWI	8,800 (detailed costs in Table 2)	CReW+
Analysis of results	4	2 weeks	UWI	1,000 to 2,000	CReW+
Final Report (A feasibility assessment outlining lessons learnt, recommendations)	4	2 weeks	UWI	5,000 to 6,000	CReW+
10% Contingency Cost					
Estimated Total Cost				**33,300 to 35,800**	

The total estimated costs of the pilot project ranges from 33,300 to 35,800 USD or 226,032 - 243,001 TTD.

7. Risk Management

The **Table 4** bellow presents the risks descriptions, their respective likelihood, impact, level and mitigation strategy.

Table 4 - Risk assessment

Risk Description	Likelihood	Impact	Risk Level	Mitigation Strategy
Delays in procurement process	2	3	Medium/High	Development and approval of TOR for execution of the pilot by September 2023 and executing agency to begin procurement process subsequently after.
Lack of coordination and communication among all entities involved in execution	1	2	Low	- Maintain update and line of communication via CReW+ monthly meeting. - Form an operation team that comprises of the MPU, the implementing partner and the executing agency for input and assistance, as required.
Delays in payments to contractors	2	3	Medium/High	

Risk Description	Likelihood	Impact	Risk Level	Mitigation Strategy
Treated wastewater from WASA does not meet the standard	2	3	Medium/High	- Seek out additional funding to solve the issue at the wastewater treatment plant -
Equipment malfunctions	2	3		- Access contingency funding to fix the equipment.
Unfavourable weather conditions, including high winds, excessive rains, severe heat	2	2	Medium/High	-
Inability to obtain truck for transporting wastewater from WASA	1	3		- Ensure WASA's commitment to dedicating a truck through a formal agreement. - Alternatively, hire contractor and obtain co-financing.
Failure to obtain treated wastewater from WASA	2	3		- Establishing a pilot Project reserve of wastewater to last the duration of the Project prior to commencement.

Risk Description	Likelihood	Impact	Risk Level	Mitigation Strategy
Tardiness in providing wastewater to the site	2	3		- Establishing a pilot Project reserve of wastewater to last the duration of the Project prior to commencement.
Crop sensitivity to nutrients used	1	2		- Persons involved have a vast knowledge of crop types and growing conditions. - Use of standard feeding practices for specific crop types.

1 – Low, 2 – Medium, 3 – High

8. Conclusion

Undertaking this pilot project to evaluate the use of treated wastewater for agricultural purposes offers a controlled and monitored setting to demonstrate its safety, viability and effectiveness.

This study assessed the quantity of treated wastewater required, and identified the necessary measurements to compare the use of treated wastewater and conventionally sourced water for common crops in Trinidad and Tobago. The experimental treatment combinations, including lettuce, tomato, and beetroot/sweet potato irrigated with treated wastewater and conventionally sourced water, will allow for a comprehensive evaluation of crop growth, development, yield, and quality. Additionally, a soil health and quality assessment are also planned after the application of treated wastewater, contributing to a better understanding of its impacts on plant health and safety parameters.

The initial pilot assessment identified that an average of 1500 gallons per week will be required to support the irrigation needs of the designated area. That means that one water truck per week would be sufficient, but two trips were planned per week in order to be able to adjust the pilot if necessary.

These findings contribute to the planning and implementation of the pilot project, ensuring that sufficient space and resources are allocated to assess the effectiveness and viability of using treated wastewater for agricultural irrigation.

However, it is important to note the challenges associated with water quality, particularly with regard to the presence of coliforms. It is essential that proper disinfection measures are in place and regularly maintained to ensure the safety and success of the pilot study.

It was identified that the current treated wastewater quality data indicated elevated coliform levels are due to inadequate cleaning of the UV tanks responsible for disinfection. Regular and manual cleaning of the tanks has shown a reduction in faecal coliforms. It is important to emphasize the importance of WASA cleaning the tanks at ideal intervals during the pilot study to maintain the water quality. **The success of the pilot project is directly impacted by ensuring the water quality meets the required standards for irrigation.**

The costs of the pilot project were estimated (including all the necessary infrastructure and analysis) at **35,800 USD**. The total pilot project duration is estimated for 4 months.

Through comprehensive evaluation and implementation of this pilot project, valuable insights can be gained to support the safe and sustainable reuse of treated wastewater in agriculture, promoting resource conservation and enhancing agricultural practices. Of prime importance, this pilot seeks to catalyse the development of programmes for the national-scale adoption of wastewater reuse schemes.

9. References

Douti, Nang Biyogue, Ebenezer Ebo Yahans Amuah, Samuel Kojo Abanyie, and Prince Amanin-Ennin. 2021. "Irrigation water quality and its impact on the physicochemical and microbiological contamination of vegetables produced from market gardening: a case of the Vea Irrigation Dam, U.E.R., Ghana." Journal of Water and Health 19 (2):203-215. doi: 10.2166/wh.2021.274.

Gashaye, Dejen. 2020. "Wastewater-irrigated urban vegetable farming in Ethiopia: A review on their potential contamination and health effects." Cogent Food & Agriculture 6 (1):1772629. doi: 10.1080/23311932.2020.1772629.

Gupta, S., S. Satpati, S. Nayek, and D. Garai. 2010. "Effect of wastewater irrigation on vegetables in relation to bioaccumulation of heavy metals and biochemical changes." Environmental Monitoring and Assessment 165 (1):169-177. doi: 10.1007/s10661-009-0936-3.

Hussain, Athar, Manjeeta Priyadarshi, and Shashikant Dubey. 2019. "Experimental study on accumulation of heavy metals in vegetables irrigated with treated wastewater." Applied Water Science 9 (5):122. doi: 10.1007/s13201-019-0999-4.

Kayombo, Mary C, and Aloyce W Mayo. 2018. "Assessment of microbial quality of vegetables irrigated with polluted waters in Dar es Salaam City, Tanzania." Environ. Ecol. Res 6 (4).

MALMR (2007), Projected Agricultural Water Requirement to the Year 2025, Land and Water Development Division, Ministry of Agriculture, Land and Marine Resources Report, Trinidad and Tobago.

Mani, Pabitra Kumar, Agniva Mandal, Dipankar Mandal, Muhammad Irfan, G. C. Hazra, and Sushanta Saha. 2021. "Assessment of Non-Carcinogenic and Carcinogenic Risks Due to Ingestion of Vegetables Grown Under Sewage Water Irrigated Soils Near a 33 Years Old Landfill Site in Kolkata, India." Exposure and Health 13 (4):629-650. doi: 10.1007/s12403-021-00407-7.

Mohammad Rusan, Munir J., Sami Hinnawi, and Laith Rousan. 2007. "Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters." Desalination 215 (1):143-152. doi: https://doi.org/10.1016/j.desal.2006.10.032.

Owusu, Victor, John-Eudes Andivi Bakang, Robert Clement Abaidoo, and Modeste Lawakilea Kinane. 2012. "Perception on untreated wastewater irrigation for vegetable production in Ghana." Environment, Development and Sustainability 14 (1):135-150. doi: 10.1007/s10668-011-9312-x.

Peters, Everson James. "Wastewater reuse in the Eastern Caribbean: a case study." In Proceedings of the Institution of Civil Engineers-Water Management, vol. 168, no. 5, pp. 232-242. Thomas Telford Ltd, 2015.

Republic of Trinidad and Tobago. 2019. The Water Pollution Rules. Caroni: Government

Printer.

Shahalam, Albulbasher, Bassam M. Abu Zahra, and A. Jaradat. 1998. "Wastewater Irrigation Effect on Soil, Crop and Environment: a Pilot Scale Study at Irbid, Jordan." Water, Air, and Soil Pollution 106 (3):425-445. doi: 10.1023/A:1005046912234.

Shakir, Eman, Zahraa Zahraw, and Abdul Hameed M. J. Al-Obaidy. 2017. "Environmental and health risks associated with reuse of wastewater for irrigation." Egyptian Journal of Petroleum 26 (1):95-102. doi: https://doi.org/10.1016/j.ejpe.2016.01.003.

Valipour, Mohammad, and Vijay P Singh. 2016. "Global experiences on wastewater irrigation: Challenges and prospects." In Balanced urban development: options and strategies for liveable cities, 289-327.

Trinidad and Tobago Bureau of Standards (TTBS). 2022. TTS 664: Wastewater Reuse – Agricultural and other Applications – Requirements. Port Of Spain.

Warricka, J. and Ekwue, E.I., 2014. Preliminary Feasibility of Large-Scale Treated Wastewater Re-use for Agriculture in Trinidad and Tobago. West Indian Journal of Engineering, 36(2).

Water Resources Agency (WRA). 2001. Integrating The Management of Watersheds and Coastal Areas in Trinidad and Tobago. The Ministry of the Environment.

Zavadil, Josef. 2009. "The effect of municipal wastewater irrigation on the yield and quality of vegetables and crops." Soil and water research 4 (3):91-103.

10. Annex

Annex 1 - Wastewater Quality data – Trincity New Wastewater Treatment Plant

WATER AND SEWERAGE AUTHORITY
OPERATIONS DIVISION
QUALITY CONTROL DEPARTMENT
QUALITY CONTROL INFORMATION SYSTEM
WASTEWATER ANALYTICAL REPORT

Trincity New Wastewater Treatment Plant

Date	Time	Weather Condition	Temp. °C	pH 6.0-9.0	Faecal Coliform C.F.U. /100mL ≤ 400	Total Suspended Solids (mg/L) ≤ 50	Dissolved Oxygen (mg/L) >4.0	Biological Oxygen Demand (mg/L) ≤ 30	Ammoniacal Nitrogen (as NH3-N) (mg/L) ≤ 10	Total Phosphorus (as P) (mg/L) ≤ 5	Nitrates (as NO3) (mg/L) ≤ 50	Inspector
21-Nov-22	8:15 AM	Heavy Rain	27	7.6	220	1	6	2	-	-	-	K. Parris
16-Dec-22	8:00 AM	Sunny	27	7.8	1500	2	4	-	-	1.9	-	K. Parris
20-Jan-23	6:30 AM	Overcast	26	7.6	45000	6	3	13	8	3.7	-	K. Parris
02-Feb-23	6:35 AM	Sunny	26	7.7	6300	8	4	-	6	3.7	-	K. Parris
15-Mar-23	6:40 AM	Sunny	27	7.4	13000	26	4	10	-	-	-	K. Parris

Prepared by:
DocuSigned by: Derek Jones
Derek Jones
Quality Control Data Manager (Ag)

Approved by:
DocuSigned by: Donna mea Davis Lewis
Donna Mea Davis Lewis
Quality Control Asst. Manager (Ag.)

TRINCITY SEWAGE TREATMENT PLANT FINAL EFFLUENT	03-Apr-23	7.6	7	6	6	240	PASS

Annex 2- Quotation for Utilization of Sewer Tanker for Reuse Effluent

CRITICAL ENGINEERING SOLUTIONS LTD.

"We goh fix that..."

Office: Lot #18 Abidh Road Extension, Cacandee Road , Felicity , Chaguanas
Phone/Fax: (868) 299-0479, 222-8189, (C) Email: criticalengsol@gmail.com
Sales-Services-Engineering Solutions
Vat Reg. No. 125208

10th May , 2023 Ref# 20230510_03

Water and Sewerage Authority of Trinidad and Tobago
Liberty Conference Centre
Hakim Juman Street
Chaguanas

Attention: Mr. John Nedd – Senior Engineer Contract Management WW

Re: Quotation for Utilization of Sewer Tanker for Reuse Effluent Pilot Project

With regards to the subject, we are pleased to provide the following quotation:

Item	Description	Quantity	Unit	Total
1.00	Transportation of the final effluent water from the New Trincity WWTP to the UWI field station at Valsayn. **Proposed Schedule: Twice per week for one month Sanitization of tanker via steaming or chlorination will be conducted.**	8	1,500.00	12,000.00
			Subtotal	**12,000.00**
			Vat (12.5%)	**1,500.00**
			TOTAL	**13,500.00**

Total = Thirteen Thousand and Five Hundred TT Dollars (Vat Inclusive)

Quote Validity: 30 days

We trust that you will find the above acceptable, however, if there is any need for further information, please do not hesitate to contact us.

Regards,

Edson Patrick
Managing Director

CRITICAL ENGINEERING SOLUTIONS LIMITED

Financed by

Co-implemented by

Co-executed by

In partnership with

CReW+