REVISTA O UNIVERSO OBSERVÁVEL

O Conhecimento
é o horizonte
de eventos.

ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

REVISTA O UNIVERSO OBSERVÁVEL

v.1, n.6, 2024 - Outubro

Revista Multidisciplinar

SMALL SCALE WASTE WATER TREATMENT SYSTEM IN SINGLE HOUSES IN SRI LANKA

Maria Vithiya e Rajeevan

https://blog.institutoine.com.br/desafios-e-solucoes-para-a-alfabetizacao-e-letramento-na-era-digital-como-se-preparar

PERIÓDICO CIENTIFÍCO INDEXADO INTERNACIONALMENTE

ISSN
International Standard Serial Number
2966-0599
www.ouniversoobservavel.com.br

REVISTA O UNIVERSO OBSERVÁVEL
O Conhecimento
é o horizonte
de eventos.
ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

SMALL SCALE WASTE WATER TREATMENT SYSTEM IN SINGLE HOUSES IN SRI LANKA

Maria Vithiya[1]
Rajeevan[2]

Revista o Universo Observável
DOI: **10.5281/zenodo.13894025**
ISSN: 2966-0599

[1]Maria Vithiya
Universidade de Jaffna
Faculdade de Tecnologia
Pais: Sri Lanka
E-mail: maryvithiya1997@gmail.com
[2] Rajeevan
Universidade de Jaffna
Faculdade de Tecnologia
Pais: Sri Lanka

REVISTA OUO UNIVERSO OBSERVÁVEL
O Conhecimento é o horizonte de eventos.
ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

Abstract
Water, an indispensable resource for both flora and fauna, is crucial for sustaining life. Wastewater, comprising utilized water contaminated with various substances like human waste, food residues, oils, soaps, and chemicals, originates from diverse household sources such as sinks, showers, toilets, and appliances like washing machines and dishwashers. Treating wastewater is vital for environmental preservation and public health. The primary objective of wastewater treatment is the elimination of suspended solids before discharging the remaining water, termed effluent, into the environment. The focus of this project is wastewater treatment in individual residences, a concern addressed through various methods globally. However, our initiative aims to introduce the Bio Digestor system for household wastewater treatment across Sri Lanka. Household water consumption is often excessive, resulting in wastage without proper treatment. Surplus treated wastewater necessitates environmentally conscious disposal methods. While connecting to municipal sewers is common, it poses environmental risks, including overflow during heavy rains and potential blockages. Moreover, different types of wastewater—greywater, blackwater, and stormwater runoff—contain distinct contaminants, requiring specific treatment approaches and disposal considerations. Our Bio Digestor system offers a versatile solution capable of treating various types of wastewater efficiently. Unlike some systems requiring extensive infrastructure modifications, ours seamlessly integrates into existing setups with minimal adjustments, making it accessible for households worldwide, regardless of location or environmental conditions. Extensive research, including surveys, field studies, and experiments, has bolstered our confidence in the feasibility and effectiveness of the Bio Digestor system. We anticipate its successful implementation and foresee its multifaceted benefits for individuals and communities, a topic we will delve into further in subsequent discussions.

Key Words: Wastewater treatment, Bio Digestor system, Household wastewater, Environmental preservation, Effluent

1. INRODUCTION

1.1. Effective Wastewater Treatment: Addressing Sri Lanka's Growing Water Needs

As global water consumption rises, the critical importance of wastewater treatment cannot be overstated. In Sri Lanka, where daily water use is significant, the treatment of household wastewater before environmental discharge is essential to prevent diseases and maintain ecological balance. The introduction of the Bio Digestor system presents an efficient and minimally invasive solution for residential wastewater management, addressing the country's need for sustainable infrastructure in this sector.

Wastewater is classified into grey water, black water, and stormwater runoff, each necessitating distinct treatment approaches. Grey water, which originates from household activities such as bathing and laundry, contains various pollutants and pathogens. Black water, composed of urine and feces, requires more intensive treatment due to its high nutrient and pathogen content. Meanwhile, stormwater runoff collects pollutants from surfaces, contributing to local water pollution and demanding robust management strategies to enhance water quality and control erosion. The historical evolution of wastewater management systems, from ancient civilizations to modern developments, underscores the ongoing advancement in this field.

The document highlights the role of anaerobic bacteria in Bio Digestors, which break down organic matter in oxygen-free environments, resulting in pollutant-free water. Current wastewater treatment methods in Sri Lanka, including septic tanks and soakage pits, are examined for their effectiveness and limitations based on maintenance needs, pollution risks, and geographic conditions.

The Bio Digestor system emerges as a superior alternative, promoting environmental sustainability and public health. This solution aligns with Sri Lanka's growing water use and the imperative for improved wastewater treatment systems to ensure a healthier and more sustainable future.

1.2. Advancing Wastewater Treatment in Sri Lanka: Challenges and Innovations

Sri Lanka's wastewater management is influenced by environmental and infrastructural challenges, necessitating careful consideration of factors such as rainfall, soil conditions, and the positioning of treatment units. High rainfall and frequent flooding necessitate robust and resilient treatment systems. The soil's capacity to absorb treated water and the gravitational flow towards treatment tanks are critical in ensuring efficient wastewater management. The integration of anaerobic bacteria within Bio Digestors demonstrates a sophisticated approach to breaking down organic matter in oxygen-free environments, effectively treating wastewater while mitigating environmental impacts.

The definition and scope of wastewater treatment encompass the separation of solids and stabilization of pollutants, essential for environmental and public health. In Sri Lanka, wastewater management involves collection, treatment, quality checking, disposal, and sludge management. Onsite disposal systems, prevalent due to the high costs associated with off-site facilities, present unique challenges during urban floods. The Bio Digestor system stands out as a viable solution, designed to treat domestic wastewater efficiently, even in areas with limited space and resources.

The economic estimation for implementing wastewater treatment systems in individual households highlights the practicality and cost-effectiveness of the Bio Digestor system. Incorporating additional filters for bathroom and laundry wastewater ensures the protection of anaerobic bacteria essential for the treatment process. The treated water, while not potable, can be utilized for various non-drinking purposes, significantly reducing household water consumption and costs. This approach aligns with global trends in water conservation and sustainable wastewater management, addressing both local and global environmental challenges.

2. OBJECTIVES

Designing a suitable domestic wastewater treatment system for single houses in Sri Lanka requires careful consideration of various environmental, economic, and practical factors. The proposed system should efficiently reduce the concentration of chemicals from household products such as soap, shampoo, and other sanitary items, thereby minimizing their impact on the environment. Additionally, the system must effectively lower Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values to ensure the treated water is safe for discharge or reuse. Economically, the design should be cost-effective, incorporating low initial setup costs and minimal maintenance requirements to be feasible for widespread adoption in Sri Lankan homes. The system should also be tailored to the local soil conditions, ensuring proper infiltration and percolation without causing soil degradation or contamination. Given the region's susceptibility to heavy rains and flooding, the design must be resilient and functional in adverse weather conditions, preventing overflow and ensuring consistent operation. The unit should be compact, allowing installation in small residential areas without sacrificing performance. Eco-friendliness is paramount, so the system should utilize natural processes and materials where possible, avoiding harmful chemicals and promoting sustainability. By integrating these elements, the wastewater treatment system can provide a practical, efficient, and sustainable solution for single households in Sri Lanka.

3. LITERATURE REVIEW

In most parts of the world, Bio Digesters are used to treat wastewater in households as well as on a fairly large scale. In India, Ghana, Nepal, and some African countries, this method is utilized for wastewater treatment. In India, Bio Digester toilets are being used in many parts (Source: Green Eco Net). Sri Lanka, being an island with a population of 21.8 million as of 2019 and covering 65,610 square kilometers, receives fairly adequate rainfall. The mean annual rainfall varies from under 900mm in the driest parts such as the southeastern and northwestern areas to over 5000mm in the wettest parts such as the western slope of the central highland (Weather Atlas / Sri Lanka). The annual renewable water resource of Sri Lanka is 52,800 million cubic meters, with a total renewable water resources (TRWR) per capita of 2531 cubic meters for the year 2009 (Source: Aquastat FAO). Total water withdrawal per capita was 638.8 cubic meters in 2005.

It has been estimated that major industrial sectors in Sri Lanka generate approximately 30 million cubic meters of wastewater per year (Source: Central Environment Authority). Estimates for other sectors and households are not readily available as the data is not compiled by any single agency. More than 70% of the wastewater produced in single households is released into the environment without any treatment or reuse (Wastewater Production, Treatment, and Use in Sri Lanka by T.B. Anand Jayalal and Nadeeka Niroshini, Director, Environmental Health and Occupational Health, Ministry of Health, Colombo, Sri Lanka). Water wastage is a global issue; according to the World Resources

ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

Institute, an environmental think tank, within the 1.3 billion tons of food wasted every year worldwide, there are 45 trillion gallons of water, representing 24% of all water used for agriculture.

Most Asian cities lack effective wastewater treatment systems. For example, only 10% of wastewater is treated in the Philippines, 14% in Indonesia, 4% in Vietnam, and 9% in India (Source: Fast Facts: Urbanization in Asia, ADB). Additionally, 4-8% of all disease burdens in Africa and developing countries in Southeast Asia are attributable to unsafe wastewater and sanitation (Source: Sanitation and Hygiene Promotion: Programming Guide, WHO 2005). According to the UN Joint Monitoring Program, less than three percent of the rural and about 12 percent of Sri Lanka's urban population discharges its toilet wastewater (black water) into sewers. However, this does not guarantee that the wastewater ends up in sewage treatment plants. In Colombo, where 90% of the below-ground infrastructure is 100 years old, more than 100,000 cubic meters of untreated sewage are discharged into the ocean through two pipes extending about 1.5 km into the sea.

We propose Bio Digesters to treat wastewater from households as a sensible solution for society. They occupy a small area, are cost-effective, easy to maintain, and well-designed, making them suitable for use anywhere on the island, whether in urban or rural areas. Implementing this method could minimize water scarcity, reduce water and power bills, and ensure proper wastewater treatment across Sri Lanka. If widely adopted, this could also boost the economy and position Sri Lanka as a role model for other Asian countries in household wastewater treatment.

4. METHODOLGY

4.1. Bio Digester

In Sri Lanka, various wastewater treatment methods are used in single households, each with its own advantages and limitations, and not all methods are suitable for every area. To address these challenges, we have designed a Bio-Digester System for treating household wastewater, a solution that can be implemented not only in Sri Lanka but globally, as seen in India, Nepal, Ghana, and some African countries. The Bio-Digester System employs anaerobic digestion to break down organic waste, producing methane-rich biogas, which can be harnessed for energy, such as generating electricity or heating the digester tank to accelerate decomposition. This system treats black water, grey water, and stormwater runoff, making the treated water suitable for gardening, vehicle washing, and, with efficient treatment, even for washing clothes and bathing. Bio-Digesters are particularly effective for rural agrarian communities, intensive livestock farms, and urban areas, where large volumes of domestic and animal waste can generate significant quantities of methane, providing a sustainable and practical solution for wastewater management.

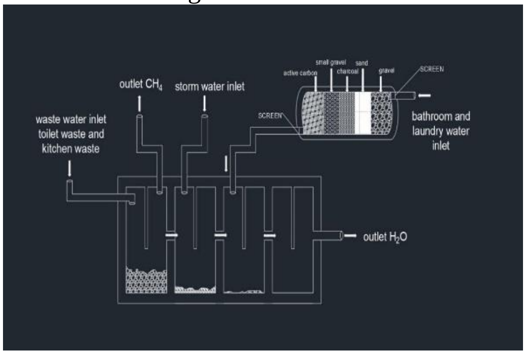

Fig 1: Bio Digestor System

The Bio-Digester system offers several advantages, making it suitable for both rural and urban areas. It can be installed above or below ground, is unaffected by climatic changes, cost-effective, and easy to set up. The system produces useful byproducts such as methane for biogas and fertilizer from sediment human excreta, without impacting the water table. However, the effluent water is not 100% pure, the tank requires periodic cleaning, and special bacteria (inoculum) must be purchased to enhance digestion. Additionally, it may release bad odors. This system operates without external energy, producing pathogen-free effluent for gardening and biogas for cooking. Initially developed by India's DRDO, it uses anaerobic bacteria to convert waste into water, methane, and CO2, inactivating pathogens responsible for water-borne diseases. Compared to traditional methods like pit latrines, septic tanks, and large sewage treatment facilities, which either contaminate the environment or consume excessive energy, Bio-Digesters provide a more sustainable and efficient alternative.

4.2. Anaerobic Digestion (Metabolism)

4.2.1. In the hydrolysis phase, complex organic molecules (proteins, carbohydrates, and lipids) are broken down into soluble monomers (amino acids, fatty acids, glucose) by hydrolytic bacteria using enzymes like cellulase, protease, and lipase. This

ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

process can be represented by the equation:

$$C_6H_{10}O_4 + 2H_2O \rightarrow C_6H_{12}O_6 + 2H_2.$$

4.2.2. In the acidogenesis phase, acidogenic bacteria transform soluble monomers into simple organic compounds, including short-chain volatile acids, ketones, and alcohols. This process occurs in an anaerobic environment and involves various facultative bacteria. If digestion were to cease at this stage, acid accumulation could inhibit further decomposition due to pH lowering. The typical acidogenesis reaction is represented by the equation:

$$C_6H_{12}O_6 + 2H_2 \leftrightarrow 2CH_3CH_2COOH + 2H_2O.$$

4.2.3. During acetogenesis, often considered part of the acid-forming stage along with acidogenesis, long-chain fatty acids, derived from lipid hydrolysis, are oxidized to acetate or propionate, generating hydrogen gas critical for anaerobic digestion reactions. Hydrogen scavenging bacteria lower hydrogen partial pressure, facilitating the conversion of all acids. The concentration of hydrogen, an indicator of digester health, must be sufficiently low for reactions to proceed.

Key reactions include the conversion of propionate to acetate ($CH_3CH_2COO^- + 3H_2O \leftrightarrow CH_3COO^- + H^+ + HCO_3 + 3H_2$),

glucose to acetate ($C_6H_{12}O_6 + 2H_2O \leftrightarrow 2CH_3COOH + 2\ CO_2 + 4H_2$),

ethanol to acetate ($CH_3CH_2OH + 2H_2O \leftrightarrow CH_3COO^- + 2H_2 + H^+$), and

bicarbonate to acetate ($2HCO_3 + 4H_2 + H^+ \leftrightarrow CHBCOO^- + 4H_2O$).

This acid-forming phase, while beneficial for acidogenic and acetogenic bacteria, decreases system pH, posing challenges for methanogenesis.

4.3. Designing

In Sri Lankan households, the existing plumbing setup suffices for wastewater treatment, with the need for no additional works. However, special consideration is required for treating bathroom and laundry wastewater due to high chemical impurities. Typically, toilet and kitchen wastewater are combined in one chamber, while stormwater settles in another. These chambers need modification with strong bases, preferably made of concrete or fiber synthetic materials. If space is limited, installation can be below the house structure, designed to withstand structural pressure. Septic tank construction must use suitable materials to withstand potential acidification from anaerobic reactions. Anaerobic bacteria (Genus Clostridium), added in powder form mixed with water through the inlet connected to the plumbing line, decompose waste into water and methane gas.

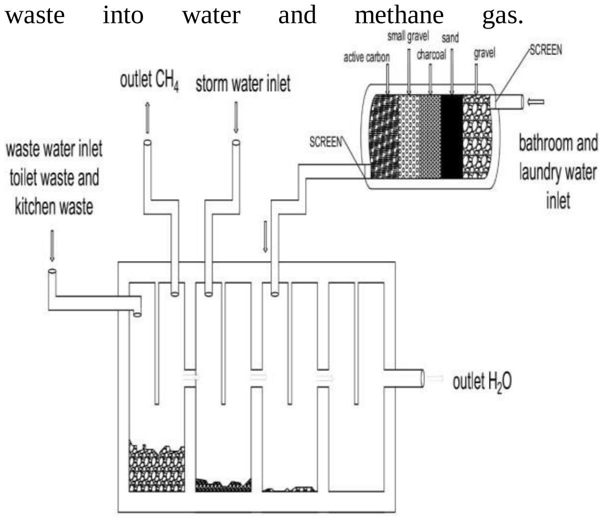

Fig 2: Bio Digestor system model

4.4. Calculation

Plumbing from the house to the Digester sewer systems are generally designed as gravity flow systems with a free water surface. This means that the sewer pipe may run full or partially full so that there is an air space above the water level (this is known as open water flow). Pumps are also used to provide the lift necessary from deep sewer locations to force the sewage to a higher deviation from which point gravity flow can continue. When a sanitary sewer system is flowing full, minimum velocities range from 2 to 2.5 ft /s. Strom sewers generally have a minimum velocity range of 3 to 3.5 ft/s. Therefore, we will use a velocity of 3.5 ft/s to determine the minimum slope required. The minimum velocity is required to prevent deposition of solids on the pipe wall Since sewer flow is open - channel flow, we can use the Manning equation for calculating the flows and pressure loss in sewer piping. The term slope is used to describe the hydraulic energy gradient in the sewer piping. The slope is a dimensionless parameter or roughness coefficient which depends on the type

REVISTA OUO UNIVERSO OBSERVÁVEL
O Conhecimento é o horizonte de eventos.
ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

and

internal condition of the pipe. The value of n ranges from 0.01 for smooth surfaces to 0 10 for rough surfaces. For sewer design, a Manning efficient of 0.013 is generally used and we shall use this value. The general form of manning equation for open channel flow is as; $V = {}^{1.486} R^{2/3} S^{1/2n}$

Here; V-average velocity of flow, ft/s

n-roughness coefficient, dimensionless

R- hydraulic radius - wetted cross-sectional area/wetted perimeter, ft

(for a circular pipe flowing full, R=(πD^2/4)

S- slope of hydraulic energy gradient, ft/ft

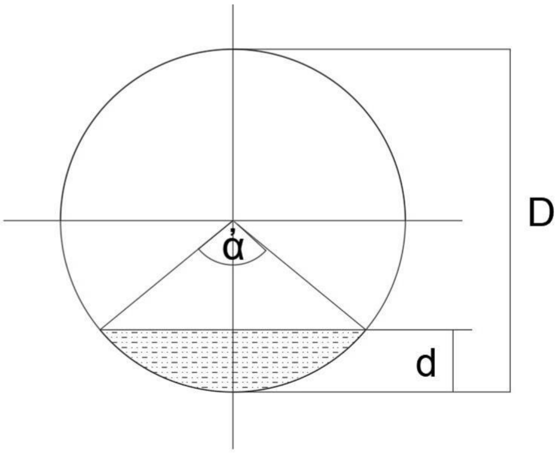

Fig 3: Partially full

There is a relationship between the water depth (d), the pipe diameter (D), and the included angle α as follows:

$$\cos\left(\frac{\alpha}{2}\right) = \frac{\frac{D}{2} - d}{\frac{D}{2}} = 1 - \frac{2d}{D}$$

The wetted area A is calculated from:

$$Area(A) = \frac{\pi}{4}\ D2\ \times \frac{\alpha}{360} - \frac{D}{2}\cos\left(\frac{\alpha}{2}\right).\frac{D}{2}\sin\left(\frac{\alpha}{2}\right)$$

Here, $P = \frac{\alpha}{360} \times\ \pi D$

Finally, the hydraulic radius R for the partially full sewer flow is calculated from

$$R = \frac{A}{P} = \frac{D}{4}\left[1 - \frac{180}{\pi}\frac{\sin\alpha}{\alpha}\right]$$

The material chosen for the construction of the digester was concrete. Concrete is more expensive compared to fiber pol septic tank on the other hand the concrete can tolerate more pressure compared fiber pols. Fiber pol also can maintain the pressure up to 150 psi. However, the both materials are suitable for construction, if any needs to made the septic tank under the house, the material should be in concrete. Otherwise, it will be damaged.

4.5. Maintenance

The septic tank's bacteria, like Psychrophile and Genus Clostridium, require regular maintenance to thrive, including annual refills. Avoiding excess waste and using soft detergents preserves their effectiveness. With a 1000-liter capacity, a family of four to five can sustain with daily usage of 600 to 750 liters. Anaerobic bacteria die off if the tank remains empty for over 15 to 20 days, needing minimal upkeep.

5. DISCUSSION

Waste water treatment is a very important part in water management. It is the removal of impurities from wastewater or sewage before it reaches aquifers or natural water bodies of water such as river, lake, estuaries, and ocean. We all knew that most amount of water is being wasted by people. Only around 10% of water is used by us and 90% is released to the environment as waste water.

To rectify this issue, many waste water treatments have been carried out in Sri Lanka and all over the world. Specially in single household. Because waste water is treated in large scale by the government or any other multi-national companies. But a very efficient single household waste water treatment system is lack in many parts of the world. There are few methods. We have thoroughly studied about those methods to carry out our project. As we have mentioned, Septic tank, soakage tank, aerated lagoons, and absorption bed are few of them. We have visited few areas to get information about these treatment methods.

We have analyzed a lot of past reports and projects about waste water treatment. And finally, we have decided to introduce Bio Digestor System to wastewater treatment in single household.

We have identified several problems related with household waste water treatment. Not all household is affordable to do waste water treatment in homes because of economic and non- availability of land or space. So, we consider this issue and provided a better solution to treat waste water efficiently in house. Bio digestor is really a good solution to these problems.

We have mentioned above all the methodology parts and how to prepare, advantages and limitation of Bio Digestor system. The constituent of waste water differs according to the location, usage and communities. We had to consider that also to do our project. All types of wastes water can be treated. As much as we researched, our bio digestor system method is suitable for all types of waste water. So, we are very proud to introduce this system to treat the waste water in every single house hold in Sri Lanka as well as other countries.

6. RESULT

The entire project work done dedicatedly. Some interruption like Covid pandemic, unfortunately the project cannot be conducted by physical experiments. Any how all statistics collected by genuine publishers. The result is based on accordance with fact.

Most of our project based on topography, geological, soil condition, food culture and the usage of consume items (detergent, soap, shampoo and etc.). Sri Lanka and south India are generally according with those things. Bio digester septic tank system is growing up technology in their country. And they got beneficial results. And most of the Indian railway departments using this technic in Railways.

In this practice the Environment should protected by harmful diseases because of the untreated wastewater and human excreta will be endangered human and animal life. The treated wastewater by this technic is not suitable for drinking purpose, anyhow the water can be used other purposes like washing, toilet flushing and agriculture. The treated water contains probably high level of nitrogen but not harmful to human, animals and environment. Therefore, that water highly recommended for agricultural purposes. It will be act like soft fertilizer. Moreover; most of the Sri Lankan households having house gardens. Therefore, this technology should be benefited to Sri Lankans and environment.

7. CONCLUSIONS

The main target of this project is design

ISSN: 2966-0599
contato@ouniversoobservavel.com.br
www.ouniversoobservavel.com.br
Periódico Científico Indexado

domestic wastewater treatment system. Wastewater produced due to human activities in households is called domestic wastewater. Main 3 types of waste water occurred. Those are grey water, black water and rain water runoff. If we discharge this wastewater without done any treatment; it not good for environment. Because daily produce large volume of domestic wastewater in Sri Lanka.

So we design Bio-digester domestic wastewater treatment system. Normally we assume 5 people in one house. Here we assume that the average household wastewater output is 1000 liters per day. This treatment system was designed for homes with limited land areas. It we can create large treatment volume; if have large or necessary space.

Here all the wastewater is collected and treated. That is black water, rain runoff water and grey water are added to the same tank and treated together. There are no bacteria in the rainwater, but all treat done to this water. Because all the wastewater will be treated by together. Then there will be an unnecessary expense and time.

The volume of one tank is 250 liters. Therefore, when a large volume comes at once, time is not enough to treat water. Then wastewater not treated well. So, by adding an extra tank to the system, if more water arrives at once, the extra volume can be stored there and added to the system late and more, not properly treated water can be re-incorporated in to the system by inserting a hole that can supply external water to the wastewater pipe. Then, the water can be re-treated.

A motor can be used to take out the treated water. When there is no electricity, treated water cannot be taken out. If the tank then filled with treated water, the treating process will temporarily stop. As a solution to this, a generator can be used to supply power to the motor when there is no electrical power.

8. REFERENCE

1. Waste water Production, treatment, and use in Sri Lanka. TB. Anand Jayalal and Nadeeka Niroshini. Director, Environmental health and occupation health, Ministry of Health, Colombo, Sri Lanka
2. Chiconato, D. And others (2013). “Resposta da alface à aplicação de biofertilizante sob dois níveis de irrigação”. Bioscience Journal, vol. 29, No. 2.
3. Motoyuki Mizuochi, Asian Environment Research Group, National Institute for Environmental Studies, Japan (2006).
4. wastewater management. (n.d.). Retrieved octomber 28, 2019, from encyclopedia: http://www.encyclopedia.com
5. National water supply and drainage board. (2019).
6. Wikipedia. (n.d.). Retrieved november 11, 2019, from septic tank: https://en.m.wikipedia.org
7. Domestic septic tanks and soakage pits. (n.d.). Retrieved november 11, 2019, from water board: https://waterboard.
8. Septic tank maintenance tips. (n.d.). Retrieved november 12, 2019, from https://scdhec.gov
9. Septic tank maintenance tips. (n.d.). Retrieved november 12, 2019, from https://www.scdhec.gov
10. Central Environmental Authority.lk
11. Greywater. (2019, march 24). Retrieved november 06, 2019, from https://www.epa.sa.gov.au