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Conceptualization of a Sustainable On-Site Sewage Management System for Building Construction with Combining Drainage Channels, Composting Facilities and Recycling Abilities

M. A. Islam[1], E. H. Shagato[2]

[1]Department of Building Engineering & Construction Management, RUET, Bangladesh (writingakib@gmail.com)
[2]Department of Mechatronics Engineering, RUET, Bangladesh (shagotohasan319@ruet.ac.bd)

Abstract

The concept provides an innovative sewage management technique for sustainable building development, addressing the negative impacts of existing sewage systems on the environment and public health. The design comprises combining separate drainage channels for greywater and blackwater, complementing on-site composting and recycling technologies. To implement this strategy, the system creates and situates drainage channels, establishes composting facility size, and outlines treatment procedures for both greywater and blackwater. This comprehensive system appropriately captures, processes, and repurposes wastewater for non-potable activities such as irrigation and toilet flushing. It minimizes external resource and energy requirements, delivering a cost-effective option that adjusts to diverse site conditions, including topography and climate. The suggested technique offers several benefits, including heightened soil fertility, improved water conservation, less dependency on external resources, and diminished environmental contamination. Ultimately, the suggested system combines separate drainage channels, on-site composting, and recycling into a flexible, economically possible, and environmentally conscientious approach for sewage management during construction. Its versatility makes it appropriate for a wide range of sustainable building scenarios, establishing it as a perfect solution for environmentally-friendly construction procedures. The technology is flexible, economical, and eco-friendly, which makes it the perfect choice for environmentally friendly building construction. The suggested system is a flexible approach to sustainable construction methods since it may be used in a range of building scenarios.

Keywords: *on-site; sustainable; composting; recycling.*

1 Introduction

Buildings shelter, support, and enclose human activities. It is usually a permanent or semi-permanent structure built to contain people, products, machines, or other significant services. A building's sewage or wastewater produced by its toilets, sinks, showers and other plumbing devices is generally referred to as "human waste collected from buildings". This waste, sometimes referred to as sanitary waste or wastewater, is made up of both liquid and solid byproducts of human biological processes (*SANITATION: A WAY OF LIFE*, n.d.). The traditional waste collection system suggests that the waste produced inside the buildings should be disposed to the natural disposable links or to be sent to a nearby treatment facility which is most presciently not found in our country. For such incidents, several water bodies are being polluted thus damaging the environment and causing an alarming situation to the flora and fauna. Although many high scale industries have purification plant on-site, but such plants are not found in the residential aspects even when residential buildings cover the most production of human waste. The goal of this paper is to propose such a building sanitation concept in which the solid waste will be separated from the liquid waste as much as possible via the sewage pipes and sent to a compost tank which will be situated on-site. This tank will be able to use those wastes and produce fertilizers and biogas which in turn will be used in several aspects. The remaining liquid waste will be sent to a water purification plant and thus, the amount of waste being exerted to the environment will lessen (or tend to zero) providing a sustainable building technology. The byproduct of this procedure such as fertilizer, bio gas and treated water can easily be used for multipurpose and it certainly be proven to be economical, sustainable and durable. Human waste is easily degradable, and the fertilizer produced is of very good manure. The PVC pipe proposed to be used has high performing abilities and biodegradable pipes if used may bring in long-lasting impacts.

2 Methodology

2.1 Experimental design

It was considered that the solid waste had reached an advanced stage, and the design and layout of the pipes were determined based on the local design and arrangements. The model was developed in SolidWorks and AutoCAD was used to portrait the overall scenario.

2.2 Pipe selection

uPVC pipes were chosen because of their smooth surface, vast availability (Ramar & Ratnaraju, n.d.), and the ease with which they could be designed. Check out all of the specifications for uPVC pipes, which are outlined in more detail in the subsequent section.

3 Conceptualization

A human DNA fragment served as inspiration for the design of the pipe's inside structure while it was being developed. Composition and treatment of water were connected along with in-site facilities after an assessment of the current situation in the country and the imperative for speedy re-generation. The greywater and blackwater at the initial phase will have two separate pipes. Here, the blackwater is considered to travel through the helical path which will be situated inside the pipe. The greywater will normally flow through a hollow pipe. While travelling through the helical path, the solids will tend to travel slower than the liquids resulting in slower transmission rate of the solids. At this moment, the solids will be shifted to a different pipe by the dint of filters situated at different portions of the propagation of the pipe. The sieve size of the filters will gradually decrease resulting in proper filtration of waste. The separated waste will be transferred to the digestion tank by the dedicated pipe and the remaining water that will be extracted from the helical path embedded pipe will meet the grey water in the septic tank below the structure.

4 Pipe characteristics

4.1 Safety & durability

Pipes must meet national health regulations. The pipeline may harm interior water, notably the drinking water. Due to manufacturing, certain plastic pipes include additives and soluble metal ions, which may affect health. After national safety testing and certification, pipes can be marketed. Water pipes should have a particular mechanical strength under the prescribed temperature and pressure and not be easily corroded by the flowing fluid to guarantee normal and long-term use (Wei, 2021). Pipe selection should prioritize corrosion and leaking. Unqualified pipes can leak water, causing significant damage that is difficult to remediate. It's simple to pollute drinking water and endanger public health.

4.2 Economic considerations

When selecting pipes, consideration was given not only to the cost of the material but also the cost of installation and maintenance. In addition, the selection of pipe diameter is affected by the pipe material. Some businesses decide to raise their prices in the hopes of drawing in more clients.

4.3 uPVC pipes

Because uPVC has a lower coefficient of friction than other materials, it was chosen for the pipes. uPVC pipes have smoother interior surfaces than other types of pipes, which makes it easier for fluid to flow through them and reduces resistance. uPVC pipes are fabricated using rigid PVC that is devoid of any additives. This results in the pipe being more durable and smoother overall. uPVC pipe reduces the amount of fluid friction, which increases the effectiveness of plumbing systems (Vlase et al., 2020).

5 Factors related to composting

5.1 Location of the composting tank

The composting tank is considered to be located at the sub structure level of the building. Because the tank will be in this position, it will be easier to keep it out of reach, and it will also be more convenient to regulate the biogas. It is recommended that the tank be positioned at a distance of at least three feet below the ground, and the soil condition must be such that the moisture content is preserved and does not seep through the walls of the tank. Because of the potential for the odor to bother those who are housed inside the structure, the biogas tank ought to be located on the building's reverse side.

5.2 Dimensions of the tank

The number of people living in a structure dictates the size of the tank, which in turn is determined by the size of the building. Owing to the fact that the lodging amenities of the building might have a significant impact on the storage of waste and sludge.

5.3 Compost mechanism

When it comes to this process, an aerobic composition will produce superior effects [4]. Composting in an aerobic environment will allow us to collect carbon dioxide (CO_2), more air, and ammonia (NH_3), all of which are essential to the functioning of our day-to-day operations.

5.4 Bio-gas and fertilizer as by product

Because only 55% to 60% of biogas is methane (CH_4) and 35% to 40% is carbon dioxide (CO2), biogas has a lower calorific value than liquid petroleum gas and around 5% of several additional gases (Awe et al., n.d.); Although the biogas design was found to have a greater initial building cost, it proved to be quite cost effective in the long term. Because of the low transportation costs associated with using biomass, this method is well suited for usage in rural areas. The method of producing biogas is beneficial to the environment since it prevents pollution of soil, water, and air (Ingole, 2015). Agricultural waste, manure, municipal trash, plant material, sewage, green waste, wastewater, and food waste are used as raw materials to create biogas, a combination of gases mostly made up of methane, carbon dioxide, and hydrogen sulphide. Improved biogas can be produced from human excreta using chicken feather powder. Within 20 days, the method would yield 6.25 percent biogas and 93.75 percent digestate from 10,000 tons of human excreta utilized in the lab (Emetere et al., 2022). Though this process will need a digester, it can be set easily if the required specifications are met. The amount of biogas produced depends on the number of inhabitants inside the building and it can be used to lessen the shortage of gas yet not eradicate. Again, high yielding fertilizers can also be obtained from this process by the help of digestion.

6 Design Procedure

6.1 Production Analysis

A human weighting 50 kg is said to produce 0.5 kg of discharge, (LGED, n.d.). For every 10 000 tons of human excreta, there is likely 3000 tons of biogas produced about 18 MJ of energy on the laboratory scale (Emetere et al., 2022). Cooking needs of 5,333 kJ per hour were accommodated by a non-continuous inverted downdraft gasifier stove that was built for a family of five (Mukunda et al., 2010). Thus, by draft estimation it can be said that by the help of a single person 1.8 kJ of energy can be found, which for a family of 5 is 9 kJ, way less compared to the actual demand. Yet this little margin can tend to put a great impact if a long run is being considered. If a 1000-liter biogas tank is utilized for two hours every day, 13 LPG cylinders may be spared per month (Varna Vishakar et al., 2022).

6.2 Pipe Design

The helical structure of the inner part of the pipe acts as the pathway for the solid waste to flow. This passage will help to glide the waste slower than the water, resulting in proper separation of solid particles. It is to be noted that this passage will tend to separate the heavier particles faster than the lighter particles, which at times may result in improper filtration but the rate of such incident is assumed to be low. The helical pathway is provided all throughout the pipe dimension (6″ in diameter). uPVC pipes provide more friction and thus results in more success ability of the concept.

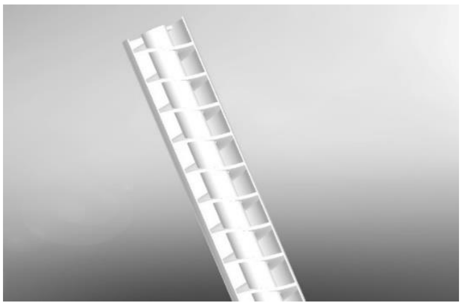

Figure 1. Cross sectional view of the proposed pipe design.

Three pipes are placed side by side. At the end of each floor of the building, there will be a filter 45° inclined with respect to the pipe. This filter will help to transfer the retain able waste materials to the other pipe which is dedicated for the solid waste and will be connected to the digestion tank.

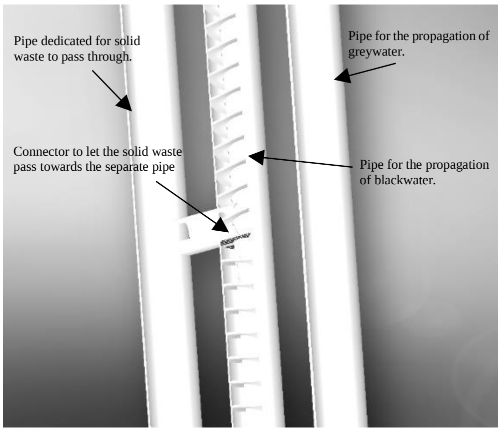

Figure 2. Illustration of separation of solid waste as modeled in SolidWorks.

This filter is made up of same materials as of the pipe. The gap between the teeth of the filter will vary from level of the pipe. The more downward the waste flows, the less it will have the openings between it. It is to be inclined at an angle of 45° because it will help the solid waste have a rapid flow towards another channel easily. The filter is quite obvious to accumulate the solids and for that there has to be a rigid water tight medium for opening the filter and cleaning it.

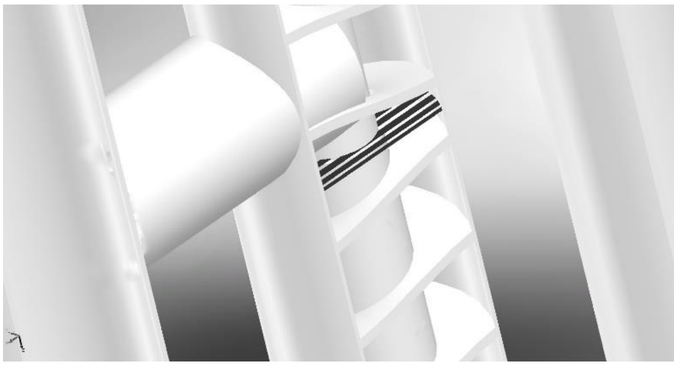

Figure 3. Detailed view of the filter which will help to separate the wastes.

6.3 Propagation towards Tank

As was stated before, the end of the uPVC pipe will typically allow for a greater volume of water to flow through it. The three pipes are going to be laid out in a line that is parallel to one another, as seen in figure 6.4. One of these will have a direct connection to the digestion tank, and it will be the one that contains the solid waste. The remaining two pipes are going to be linked to the septic tank, which is going to be used to store the liquid waste until further action is taken.

6.4 Transporting to Local Water Treatment Plant

The last water that is collected is required to be sent to the community's water treatment facility. There, the water will be cleaned and reused once it has been recycled for a second time. It is important to note that the treatment method must be altered in order to accommodate for the possibility that this water may potentially contain certain particles of solid waste or bacterial particles.

6.5 Usage of the Fertilizers

There will be a significant increase in the manufacture of organic fertilizers, which are, in all honesty, pretty beneficial to the health of the environment. The fertilizing capacity of organic fertilizers are superior to that of chemical fertilizer, and in addition, organic fertilizers is generally better for the environment than chemical fertilizer are.

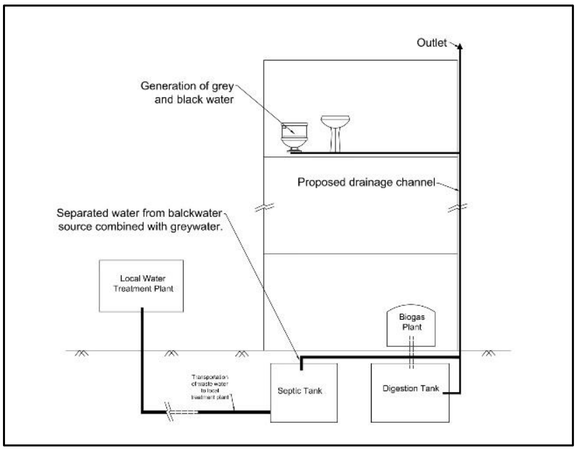

Figure 4. Illustration of propagation of waste water to various designated destinations.

7 Conclusion

The fundamental purpose of this research is to find ways to enhance sanitation services for people all around the world while simultaneously working towards the goal of achieving sustainability. This process will help facilitate the creation of a variety of important end products, including the recycling of water, the manufacture of fertilizers, and the production of biogas. The fact that all of these materials come from renewable sources indicates that the usage of these materials would result in an increase in the building's sustainability, which would be beneficial to the tenants of the building. If we want to realize the full potential of this idea, we are going to have a difficult time doing so because every single structure in our nation is constructed with rooms that are nearly identical to having their very own bathrooms. On the other hand, if we move towards the western style of building design, we will see that many structures have a tendency to have a single toilet that is shared by all of the residents who live inside the building. This is because the western style of building design prioritizes space efficiency. This will make a smaller load for us to bear. This approach can also be used while we are conceiving of the ideas that were discussed earlier, which will finally lead to an improved sanitation system for our society. Above all else, the resources of our planet Earth are diminishing at an alarming rate. As a consequence, it is high time for us to implement practices that encourage sustainability and the renewability of all materials in order to conserve our supplies. In other words, the clock is ticking.

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