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Development and Analysis of Sewage Treatment System using Hydrous Pyrolysis

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Abstract : Today humankind is facing acute shortage of water due the uncontrolled pollution and excessive usage of water. The cause of various diseases is the contaminants in water, so it is important to recycle and reuse water to maximum extend. Inadequate treatment of wastewater allows bacteria, viruses, and other disease-causing pathogens to enter groundwater and surface water and contaminate, so there is need for effective Onsite treatment system. In order to meet this demand of water and to provide a better wastewater system, an attempt has been made to design a Onsite sewage treatment system employing the technique of Hydrous pyrolysis. This treatment system is to be employed in the place of septic tanks in domestic and Industrial buildings. A model of Hydrous Pyrolysis Treatment System is constructed using suitable material and sewage water is treated and the corresponding results are stated. The advantage of this system is compared with other methods of sewage treatment.
Keywords : Sewage water, Treated water, Prototype, Hydrous Pyrolysis Treatment (HPT) system.

Introduction

Sewage/Wastewater are essentially the water supply of the community after it has been fouled by a variety of uses[1]. Pollution in its broadest sense includes all changes that curtail natural utility and exert deleterious effect on life. The crisis triggered by the rapidly growing population and industrialization with the resultant degradation of the environment causes a grave threat to the quality of life. Degradation of water quality is the unfavorable alteration of the physical, chemical and biological properties of water that prevents domestic, commercial, industrial, agricultural, recreational and other beneficial uses of water. Sewage and sewage effluents are the major sources of water pollution. Sewage is mainly composed of human fecal material, domestic wastes including wash-water and industrial wastes[2]. Sewage is a mixture of domestic and industrial wastes. It is more than 99% water, but the remainder contains some ions, suspended solids and harmful bacteria that must be removed before the water is released into the sea[3]. Sewage is a major carrier of disease (from human wastes) and toxins (from industrial wastes). The safe treatment of sewage is thus crucial to the health of any community.The growing environmental pollution and the need for the water recycling effectively results in designinga onsite wastewater treatment system using some improved techniques and technologies replacing the convectional septic tank. Presently in this design hydrous pyrolysis has been employed. Centralized sewerage systems are usually the best method of sewage management in urban areas and in rural residential areas where a council water supply is available. This is because there is generally insufficient land to sustainably manage all the wastewater in these areas[4]. Need for the treatment system which can be imparted in the place of septic tanks in residential and Industrial buildings.

Sampling techniques and Analysis:

Sewage water samples have been collected in contamination free sampling bottles of 1000 ml (Turson make) from the septic tank.Preliminary test is carried out in order to find the various parameters involved in hydrous pyrolysis treatment system in water treatment and recycling, In this test the HPT model is used, the sewage water is recycled. The obtained water is analysed and the efficiency and applicability of HPT is checked.

Construction Process

Nichrome Rod, Thermocouple, Water Level Controller, Toughened Glass, Cuddaph Stone, GI Pipe following are suitable fabrication materials selected for the construction of HPT model.

HPT System

A model Hydrous Pyrolysis Treatment System unit is constructed using the described fabrication material. And this model is used to treat sewage water which intern gives treated water.

Design of the model

The objective of the design is to make the system simpler in complexion and easier for handling, the dimensional requirements are sorted out in reference to the standard values available, design is to be made in such a way that the assembly of the equipment to be carried out with ease by both skilled and non-skilled labour, To ensure the process is being efficiently carried out with at most safety.

Volume of the Tank

Let the dimensions of the tank be assumed that can be practically constructed in small scale as a model. The dimensions of the chamber 1 be higher than the chamber 2 since various fabrication works and parts are involved in it.Total volume of a rectangular prism shaped tank is length times width times height. Therefore,The filled volume of a rectangular tank is just a shorter height with the same length and width. The new height is the fill height or f shown in Table 1.

Table 1.Volume of the Tank

Chamber 1	**Chamber 2**
Length of the tank (l) = 1 feet	Length of the tank (l) = 1 feet
Width of the tank (w) = 1 feet	Width of the tank (w) = 1 feet
Height of the tank (h) = 1 feet 6 inch	Height of the tank (h) = 1 feet
Volume of the tank be = 1’ x 1’ x 1’6” feet **= 42.47 lits.**	Volume of the tank be = 1’ x 1’ x 1’ = **28.31 lits.**
Volume of the fill = 1’ x 1’ x 1’ **= 28.31 lits.**	Volume of the fill = 1’ x 1’ x 1’= **21.23 lits.**

Construction of Chambers

In Chamber 1, the heating process is to be involved hence the chamber is constructed using Cuddapah material and the Nichrome rod is inserted in order to provide heating to the sewage and also to indicate the sewage water level in the tank properly, a water level controller probes are fitted in the appropriate heights.The Chamber 1 showing the entire set-up, with Nichrome rod, Probes and Trans-Funnel. Shown in Figure 1.

Figure 1The Chamber 1 showing the entire set-up, with Nichrome rod, Probes and Trans-Funnel

In Chamber 2, the condensation process is to be taking place in order to support it and to visible see the condensation process a toughened glass is used in one side of the tank and a cooling tile with a slope is used at the bottom for easy flow of the water towards pipe shown in Figure 2.

Figure 2 Chamber 2 showing the top and side view

The connection between chamber 1 and chamber 2 is made through a self-made transfer pipe, the one end of the transfer pipe is inserted into the chamber 1 and other side of the pipe is inserted into the chamber 2, these two sides are made separately and coupled together.The one end of the transfer pipe which is connected to the chamber 1 has a funnel shaped inlet side in order to capture more steam and make it to transfer and also this funnel has a mesh or filter welded to it this is to ensure or prevent the small solid particles in the steam to enter chamber 2 shown in Figure3.The other end of the transfer pipe which is connected to the chamber 2 has a one way flow system of design and making. This is to ensure that no steam return backs to the chamber 1 from chamber 2 shown in Figure 4

Figure 3 Side View of the Funnel end of Transfer Pipe

Figure 4 Chamber 2 end transfer pipe

Providing electrical Connection with Nichrome rod

The Proper electrical connection is very necessary in order to establish proper heating system, hence first the positive and neutral ends of the rod is found the it is connected with 520 mcm copper wire is used, with proper end connection.

Providing other electrical connection

The water level controller is connected with the probe in appropriate places and also the water level controller is fitted with the bulb for indication of top level and end connections are made to connect it to the electrical circuit.Shown in Figure 5.

Figure 5 Wire Connection

Finishing

The entire chamber 1 and chamber 2 is finished by packing the gaps and all the sides of both chambers using a water proof solution shown in Figure 6.

Figure 6 Complete HPT system

Process involved

Hydrous pyrolysis refers to the thermal decomposition which takes place when organic compounds are heated to high temperatures in the presence of water and this water being converted to steam, then this steam can be transferred to another chamber and cooled down to water again. The process involved in this HPT system can be understood in detail by the following chart.Shown in Figure 7.

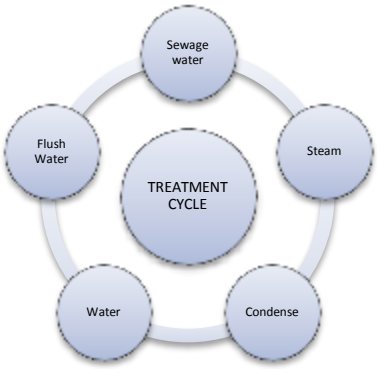

Figure 7 Process Flow Diagram

Sewage water - water-carried waste in solution or suspension that is intended to be removed from a community. Also known as wastewater, it is more than 99% water and is characterized by volume or rate of flow, physical condition, chemical and toxic constituents, and the bacteriological organisms that it contains. It consists mostly of greywater (from sinks, tubs, showers, dishwashers, and clothes washers), the water used to

flush toilets, and the human waste that the toilets flush away; soaps and detergents. The water content in the sewage is pretty more hence we target it. The sewage water is collected in the chamber 1 through inlet. This water is heated to convert the water to steam.

Steam is the state of water in gases form and this steam may also have few losses. All too often, steam traps are selected and installed, only to be forgotten. All steam traps fail with time. On average, plants without a regularly scheduled maintenance program experience failure in about 15-25 percent of their traps at any given time. Which may lead to steam loss.

Condensation- The condensation of the steam depends upon the following factors,Control Valves and Equipment: Sizing and dimensions of control valves & equipment in steam and condensate systems.Flash Steam:Flash steam generation - thermodynamic fundamentals, heat loss, energy recovery and more**.** Heat Loss and Insulation:Steam and condensate pipes - heat loss uninsulated and insulated pipes, insulation thickness and more**.** Pipe Sizing:Sizing steam and condensate pipes - pressure loss, recommended velocity, capacity and more**.**Thermodynamics:Thermodynamics of steam and condensate applications**.** Air Humidifying with Steam - Imperial Units:Amount of vapor (lb/h in 100 cfm) in humid air.

Water- The water is been condensed and liquefied due to the surrounding normal atmospheric temperature. This water formed may lesser in content due to the losses involved throughout the process.

Flush water- More than 45% of water use in the average Indian home occurs in the bathroom, with nearly 27% being used by toilets. Fortunately, your household can significantly curb its toilet water usage by regularly checking for and fixing leaks, retrofitting older toilets, or installing a new toilet. The treated water is to be taken to the flush water tank and can again be used in the same flushing purpose of the latrines.

Results and Discussion:

Heating Time

Thermo couple and a data logger to generate a graph between time and temperature. 1 lit of sewage water is taken and time of heating and its corresponding temperature is measured. 20 lit of sewage water is taken and time of heating and corresponding temperature is measured shown in Table 2 and Figure 8.

Table 1 shows Time vs Temperature

Time	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Temperature	22	22	25	31	38	45	51	59	68	75	83	90	97	100	100

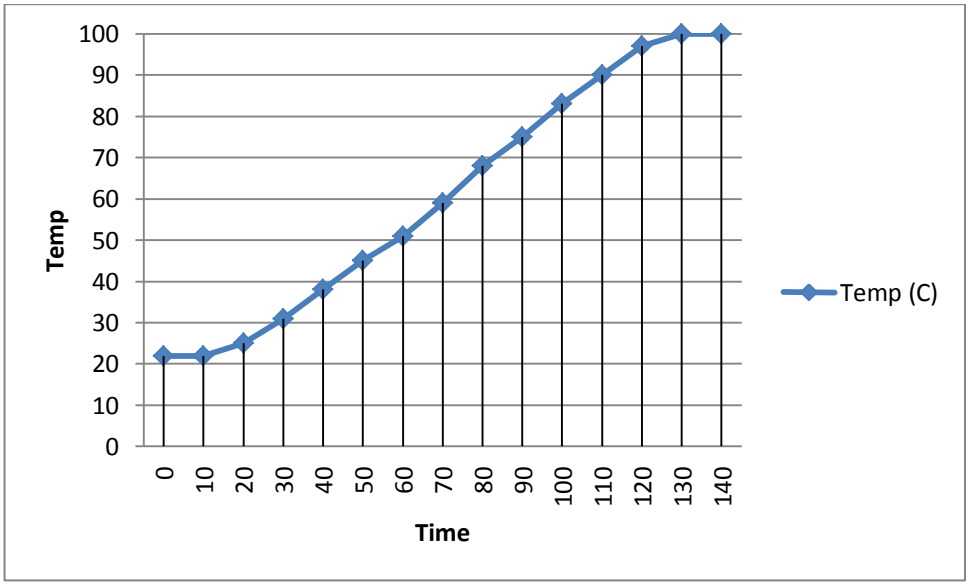

Figure 8 Shows the graph Time vs Temperature

Cost estimation on heating

Energy used for the quantity of substance and their cost of heating shown in Table 2 and Figure 9. Boiling 1 lit of sewage water is calculated as follows: Heater – 3 kW**,** One unit cost – 280 ps**,** Heating time – 140 sec or 2.33 mins**,** Cost of heating per minute – 14 ps, Total cost of heating – 14 x 2.33 = Rs. 0.32. Boiling 20 lit of sewage water is calculated as: Heater – 3 kW, Heating time – 70 mins, Total cost of heating – 14 x 65 = Rs. 9.10

Table 2 shows the energy used for the quantity of substance and their cost of heating

Trail	Quantity of substance	Energy used	Cost of heating
I	1 lit	0.11 unit	32 ps
II	1 lit	0.14 unit	40 ps
III	28 lit	8.22 unit	Rs.23
IV	28 lit	10.28 unit	Rs.29
V	20 lit	9.14 unit	Rs.25.50

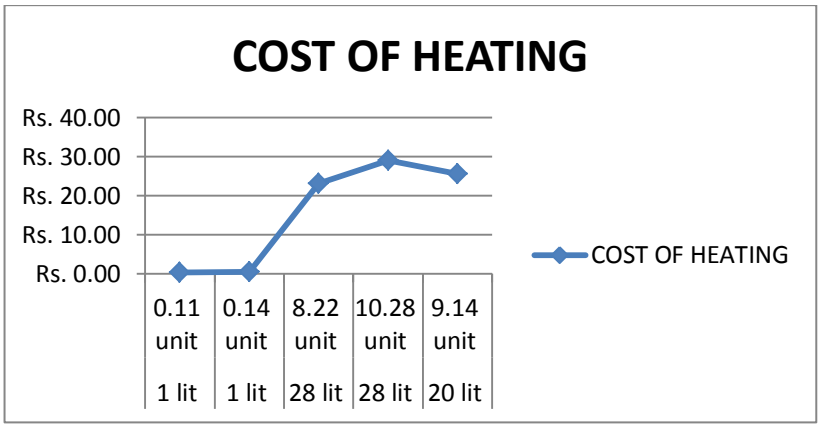

Figure 9 shows graph on the power usage and generation

Water Heater efficiency

The energy factor (EF) indicates a water heater's overall energy efficiency based on the amount of hot water produced per unit of fuel consumed over a typical day. This includes the following:Recovery efficiency – how efficiently the heat from the energy source is transferred to the water. Standby losses – the percentage of heat loss per hour from the stored water compared to the heat content of the water (water heaters with storage tanks). Cycling losses – the loss of heat as the water circulates through a water heater tank, and/or inlet and outlet pipes.

Trials conducted using HPT model:

There are about five trails conducted using HPT model and the results are

Shown in table 3

Table:3 Trials Conducted Using HPT Model

Trails no	Substance	Density (kg/m^3)	Quantiy of inlet	Heating time	Condensation time	Quantity of recycling	Efficiency
I	Tap water	1000	1 lit	125 (sec)	-	-	-
II	Sewage water	1005	1 lit	130 (sec)	-	-	-
III	Fresh water	1000	28 lit	72 mins	3 hours	11 lits	39 %
IV	Sewage water	1004	28 lit	90 mins	3 hours	9 lits	32 %
V	Sewage water	1004	20 lit	80 mins	5 hours	10.5 lits	52.5%

Recycled water Characteristics and comparison:

The Characteristics of the sewage sample was determined and also for comparison the Kitchen waste water Characteristics and the tap water characteristics were determined and tabulated in Table 4,5.6.7&8.

Table:4 Determination of pH of the sample

Source	pH
Sullage waste water	7.89
Sewage waste water	8.9
Tap water	7.5

Table 5 Determination of turbidity of Sample

Source	Value In NTU
Sullage waste water	116
Sewage waste water	212
Tap water	15

From Table 4 and 5It is clear that turbidity and pH of the sewage water is higher and not suitable at all. Here utilization of sulphuric acid is used is zero. Thus it indicates presence of bicarbonate.

Table 6 Determination of alkalinity

Source	Conc. In PPM
Sullage waste water	75
Sewage waste water	350
Tap water	18

Table 7 Characteristics of the Treated Water

S. No	Characteristics	Value
1.	pH	7.8
2.	Turbidity	20 (in NTU)
3.	Alkalinity	68 (conc. in ppm)

Table 7 gives the of treated water to its corresponding characteristics and observations are noted down

Table 8 Comparison Between Sewage Sample And Treated Sample Water.

S. No	Characteristics	Sewage Sample	Treated Sample
1.	Odour	Rotten Egg, Foul	No odour
2.	Colour	Grey	Whitish colour
3.	Floatables	Little quantity	No Floatables
4.	Turbidity (in NTU)	212	20
5.	Alkalinity	350	68
6.	pH	8.9	7.8

The characteristics and the value of the sewage sample and treated sample were compared and the observations are noted.

Comparison between Conventional method and HPT system

The conventional septic tank has number of disadvantages such as,Overflow of the tank, Seepage of water, Pollution of underground water**,** Pollution of environment during extraction by pumping**,** Health effects during overflow**.**The advantage of HPT over other methods such as, Recycling of water for flush**,** Eliminates the possibilities of overflowing**,** Environmental friendly**,** Underground water is not affected**,** Easily reliable**,** Implemented in residential apartments and Industries as a replacement to Conventional septic tank

Conclusion:

The Characteristics of Sewage water sample and treated water sample quality experimented and found out.From the comparison between the characteristics of sewage water sample and treated water sample, the treated water characteristics gave better results and also nearly fits the standards.The HPT treatment is eco-friendly and very reliableEliminates most of the disadvantages of conventional septic tank.The HPT system is cost-effective when compared to other methods. HPT system requires less space than other treatment systems. Hence HPT system can be taken as a alternative to the septic tank and the model is the proof to it.

The Characteristics of Sewage water sample and treated water sample quality experimented and found out. From the comparison between the characteristics of sewage water sample and treated water sample, the treated water characteristics gave better results and also nearly fits the standards. The physical characteristics such as colour and odour of sewage water and treated water showed a much difference, the colour of waste water was in grey whereas the colour of treated water was whitish, also the foul smell was eliminated.

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