Design and Fabrication of Automatic Sewage Cleaner

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Abstract **-Sewage systems play a crucial role in managing urban wastewater, but they often face blockages due to the accumulation of non-biodegradable waste materials. These blockages result in overflow, leading to flooding and various associated problems. Common culprits for clogs include nylon, plastic, bottles, and empty cans that find their way into the sewer system. Currently, clearing these obstructions is a costly and sometimes hazardous process, involving either suction machines or manual intervention, jeopardizing the health of unskilled workers. In this research, we present the development of an innovative solution, an Automatic Sewage Cleaner, designed to effectively clear sewage system blockages. Unlike traditional methods that are weather-dependent and inefficient, our system operates consistently, regardless of weather conditions. Moreover, it ensures the proper disposal of the separated solid waste, preventing littering in the surrounding areas.**

Keywords: **waste products, drainage system, non-biodegradable, sewage system, solid wastes, sewage system cleaning, and drainage pipes.**

1. INTRODUCTION

Sewage, wastewater, and rainwater management are essential components of urban infrastructure, relying on an extensive network of underground drainage systems and gutters to transport these fluids away from residential areas [1]. The proper maintenance of these drainage systems is of paramount importance, as neglect can lead to a host of significant problems. Foremost among these issues is waterlogging, a condition that poses a multifaceted threat to both the structural integrity of roads and the well-being of human and animal populations [6].

Waterlogging, if left unchecked, can undermine the very foundations of road structures that serve as conduits for these drainage systems [6]. In addition to compromising infrastructure, waterlogging can engender a spectrum of health hazards [2]. Diseases like Tuberculosis, Pneumonia, Diarrhea, Tetanus, and Whooping Cough can proliferate in areas affected by stagnant water [6]. Furthermore, the breeding grounds for disease-carrying mosquitoes, such as those responsible for Dengue and Malaria, are readily established in waterlogged regions [6]. The stench and discomfort associated with waterlogged areas contribute to the degradation of the living conditions for residents in proximity to these zones [6].

The accumulation of waste and debris within these drainage systems can yield harmful gases, including methane and carbon dioxide, exacerbating environmental concerns [4]. The current practice of manual cleaning of these sewage lines poses not only physical hazards but also ethical questions regarding the well-being of the individuals tasked with this perilous work [8]. Prolonged exposure to water laden with sewage waste is a life-threatening occupational risk [8].

This research paper aims to introduce an innovative solution to these pressing challenges through the development of an Automated Sewage Cleaner [8]. By automating the sewage cleaning process, the project strives to minimize human involvement and direct contact with waste matter, significantly enhancing safety and efficiency [8]. The potential applications of this equipment extend beyond residential areas, as it can find utility in industrial contexts for cleaning interconnected canals and in agricultural settings for canal maintenance [8]. The goal is to provide a comprehensive solution that mitigates risks, reduces human effort, and ensures the effective management of drainage systems [8].

The basic objective of this research is to find a solution for various problems caused by sewage waste, to develop an automated drain/gutter cleaner to reduce human efforts, to overcome the problem of waterlogging caused by over flooding of sewers because of excessive waste and to stop the spread of various waterborne diseases caused by waterlogging and to stop breeding of mosquitoes and health hazards related to mosquitoes [8].To prevent cleaner's direct contact with the sewage waste [8].

2. METHEDOLOGY

Before the design and development of the working model, following points have been considered carefully.

2.1.1. Improper sanitation causing sewage problem:

The fact that "half of houses have phones but no toilets" and that the government of India and charity organizations work tirelessly to supply toilets to the 48 percent of Indians who do not have access to one imply that having adequate toilets would resolve India's sanitation issues. While toilets are a crucial component of the answer, India's sewage management is perhaps a more pressing yet sometimes disregarded problem. Currently, 93% of sewage makes its way untreated to ponds, lakes, and rivers.

Untreated sewage is the leading cause of water pollution in India, which also causes dirty farmland, environmental devastation, and a variety of ailments such as diarrhea, which kills 350,000 Indian children each year. The urban poor are often located near untidy canals and drains, which are breeding grounds for viruses and mosquitoes.

Centralized sewage systems contain underground pipelines, pumping stations, and treatment facilities in India's main cities. These systems require constant power, specialized operators, and substantial maintenance, making them expensive to build and run. As a result, less than half of them, according to India's Central Pollution Control Board, work efficiently. Furthermore, such systems are out of reach for smaller communities in India. The good news is that a few companies are working on more affordable and efficient sewage systems. The Consortium for Decentralized Wastewater Treatment System Dissemination Society (CDD) is one of them. It is a non-profit organization that has been developing and promoting decentralized wastewater management technology since 2002.

The Decentralized Wastewater Treatment System (DEWATS), which has numerous technological adaptations for environments where electricity is not always reliably available, skilled labor is in short supply, and mechanical parts that break may never be repaired, was developed by CDD with assistance from the Bremen Overseas Research and Development Association.

2.1.2. Untreated sewage waste:

The government has four years to fulfil its objective of having all Indians use toilets, but just 30% of the wastewater generated by the 377 million people living in urban India is treated. According to an Indian Spend review of a variety of sources of the remaining is indiscriminately thrown into rivers, seas, lakes, and wells, poisoning three-fourths of the country's water bodies. According to official data from December 2015, urban regions produce around 62,000 million litres per day (MLD) of sewage, but India's treatment capacity is just 23,277 MLD, or 37% of the sewage produced.

This data also shows that 522 of the 816 municipal sewage treatment plants (STPs) registered in India are functioning. In other words, the capacity claimed is 23,277 the MLD versus 62,000 MLD, yet just 18,883 MLD of sewage gets processed. As a result, just 30% of sewage generated in urban India is treated. According to the Central Pollution Control Board's (CPCB) Envenomation Of Sewage Treatment Plants study, there are 79 inoperable STPs, 145 under construction, and 70 planned.

India's villages and towns continue to contaminate their own water supplies over time. According to Water Aid's Faucal Sludge Management report, which cites a 2009 CPCB report, sewage generation in India is estimated to be 38,255 MLD from class-I urban centres (with populations of in excess of 100,000) and class-II towns (with a the number of people of 50,000-100,000), with only 11,787 MLD (30%) being treated. Untreated sewage is thrown straight into bodies of water, damaging three-quarters of India's aquifer funds, according to FSM research. According to the findings, up to 80% of bodies fluids may be poisoned. According to the CPCB's 2009 assessment, existing treatment capacity and upkeep is below par, with 39% of facilities failing to comply with environmental rules for discharge into streams.

Figure 2.1.2 Untreated sewage waste

2.1.3. Sewage treatment plant

Following is a table of various sewage treatment plants in various states like Punjab, Maharashtra, Tamil Nadu, Uttar Pradesh, Himachal Pradesh, and a column for overall India. It shows Capacity of municipal STPs, Total municipal STPs, Operational capacity, STPs Operational, Non-Operational STPs, STPS under construction, proposed STPs.

Table 2.1.3.. Sewage Treatment Plants (STPs)

State/UT	Punjab	Maha-rashtra	Tamil Nadu	Uttar Pradesh	Himachal Pradesh	All India
Capacity of Municipal STPs (MLD)	1245.45	5160.36	1799.72	2646.84	114.72	23277.36
Total Municipal STPs	86	76	73	73	66	816
Operational Capacity (MLD)	921.45	4683.9	1140.83	2372.25	79.51	18883.2
STPs Operational	38	60	33	62	36	522
Non-Operational STPs	4	10	1	7	30	79
Under Construction STPs	31	6	28	3	-	145
Proposed STPs	13	-	11	1	-	70

2.1.4. Manual scavenging:

Cleaning sewers or removing garbage from toilets by hand without safety equipment is known as manual scavenging. Simply put, untreated human excreta are collected by hand using buckets or shovels from pit latrines or bucket toilets. According to the International Labor Organization, there are three types of scavenging: cleaning septic tanks, removing human waste from dry latrines, and cleaning gutters and sewers. Manual scavengers employ simple equipment like a handle and a bucket that is lined with a bag. The employee then transports the material physically to the disposal locations. Manual scavenging is seen to be illegal and inhumane. It includes issues that touch on the areas of health and employment, social justice and human rights, gender and caste, and human dignity. In places without efficient sewage facilities, like the Badan district in India, where there are more than 50,000 manual scavengers, this practice is common.

III. DESIGN & CALCULATIONS

3.1.1 Base Frame

Total load on frame is about 15kg

$F = m \times g$ = 15 × 9.81 = 147.15 N

This load is applied at the centre.

3.1.2. Selection of Motor

Speed (N) = 30 rpm

We suppose the weight of garbage = 3 kg

Pulley distance is =0.05 m

FOS = 1.5

Force = 3 × 9.81 = 29.4 N

Torque = Force × Distance = 29.4 × 0.05 = 1.47 N-m or 1470 N-mm

Maximum Torque = 1.47 × 1.5 = 2.205 N-m or 2205 N-mm

Power = (2πNT)/60 = (2π × 30 ×2.20)/60 = 6.911 watts. □ 7 watts.

Therefore,

Selecting motor of power of 7 watts so losses can be avoided.

Voltage: 12 volt

Current: 5 amp

Speed: 30 rpm

3.1.3. Design of Shaft

Power: 7 watt

Speed: 30 rpm

assuming load factor Kl: 1.75

(From design data book, assuming electric motor)

T= 60×Pr × (Kl/2) × π × N

=60×7 × (1.75/2) × π×30

T=34.6 N-m

S_{yt} = 250 for material Mild Steel.

Take FOS=1.5

t=S_{yt}/ (2 × FOS)

t=250/(2 × 1.5)

t=83.33 MPa.

Applying maximum principle shear stress theory.

□=$16T/\pi\times d^3$

59.2= $(16\times37.11\times10^{3)}$ /$(\pi\times d^3)$

d=12.83 mm.

Considering bending stresses

d=12.83 ×1.5

d=19.25 mm.

d=20 mm

3.1.4. Selection of Bearing

Bearing selection is entirely dependent on shaft diameter; in this case, we chose an entirely secure shaft with a circumference of 20 mm. Because the shaft has a diameter of 20 mm, we utilized a bearing with an inside diameter of 20 millimeters. The pedestal's bearing no. 204 is utilized.

3.2.1. Components Selection:

Figure 3.2.1 Square Pipes

A shaft is a rotating machine part that transfers energy from one part to another or from a machine that generates energy to a machine that consumes energy. Most shafts have round cross sections. It is mounted with different parts, including pulleys and gears. In this case the shaft used is of material bright bar shaft.

Bright bars are raw materials made from stainless steel alloys utilizing the cold drawing process in a cold reduction mill. The name "Bright Bar" relates to its flawless geometric molecular structure, which has an unusually smooth surface finish that always seems dazzling. It is mostly made of stainless steel, with varying additions of carbon and traces of other elements like chromium, manganese, iron, etc.

Bright bars are raw materials produced in a cold reduction mill by cold drawing stainless steel alloys. The phrase "Bright Bar" refers to the brilliantly dazzling surface finish of the flawless geometric molecular structure. It is mostly made of stainless steel, with varying quantities of carbon additions and traces of other metals like chromium, manganese, iron, etc. This bar provides stability, strength, and durability to giant structures. Bright bars are produced from cold drawing stainless steel alloys used as raw materials in a cold reduction mill. The name "Bright Bar" refers to the brilliantly glittering surface polish of the flawless geometric molecular structure. It is mostly made of stainless steel, with varying levels of carbon additions and traces of other metals like chromium, manganese, iron, etc. The most used round bar grades include 201, 202, 304, 309, 316, 316L, 316, 321 and the 400 series.

3.2.2. Square Pipes

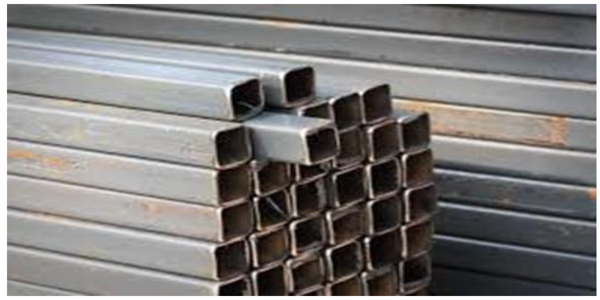

Figure 3.2.2 Square Pipes

Square pipes have been used for the construction of the base frame

We may use structural steel or metal objects like square pipes to establish a network of building columns. This is one of its finest uses since square pipes can withstand a variety of loads despite the wide range of materials. The hollow shape of the square pipes enables the support of heavy weights. It could even be preferred because of the tube's light weight and likeness to other solid-shaped building materials. Compared to PVC, wood, or pure concrete, the tubes' strength to weight ratio has improved.

3.2.3. DC Motor

Figure 4.2.3. DC Motor

A DC Motor rotates the shaft and is the main driving element of the machine. The technical specifications of the motor are as follow-:

T555 12V 30 RPM Rectangular gearbox DC motor. Rated Current (mA)- ≤ 2000. Rated Power (W)- 5.624. Rated Torque (N-m) - 1.983 (20 Kg-cm). Rated Speed – 30-40 RPM. Base Motor RPM - 4500

3.2.4. Specifications of Chain

The chain is the main moving element of the machine. It is connected on the sprocket which is rotated by the shaft on which it is mounted. The chains need to be of good quality so that it can carry the load which is to be lifted by the lifter mount. The chain used in the project is Rainbow CHAIN-08B-1.

3.2.5. Sprocket

Figure 3.2.4. Sprocket

A sprocket or sprocket-wheel is a profiled wheel with teeth, or cogs, that mesh with a chain, track, or other perforated or indented material. A sprocket is any wheel having radial projections that engage a chain passing over it. Sprockets differ from gears in that they never mesh directly with one another. Additionally, sprockets have teeth, whereas pulleys are smooth, which makes them different from pulleys. In bicycles, motorbikes, cars, tracked vehicles, and other machinery, sprockets are used when gears are insufficient to convey rotational motion between two shafts. They can also be used to give a track, tape, etc. linear motion. The bicycle may have the most common style of sprocket, with a large sprocket-wheel located on the pedal shaft, a chain, and a small sprocket put on the axle of the rear wheel. Also, most early automobiles were propelled by a sprocket and chain system, heavily influenced by bicycles. Sprockets come in a number of styles, and each designer promises that it performs as efficiently as possible. Sprockets often don't have a flange. Some sprockets used with timing belts include flanges to keep the timing belt centered. Sprockets and chains are also employed to transfer power from one shaft to another when slippage is not allowed, with sprocket wheels replacing pulleys and sprocket chains replacing belts or ropes. They can be operated at high speeds, and certain varieties of chain are constructed such that they can run at high speeds without making a sound. Here, a mild steel sprocket is being used.

Specifications -: Outer diameter – 100 mm

Inner diameter – 15 mm Teeth – 21

3.2.6. Bearing

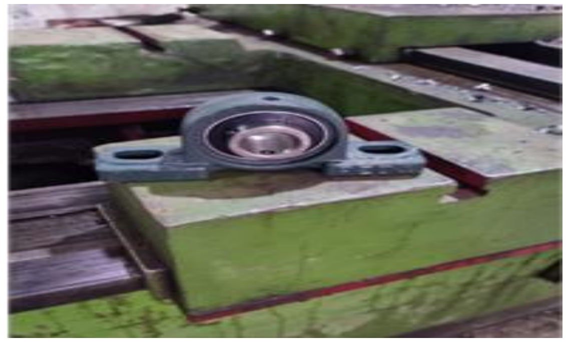

Figure 3.2.5. Bearing

A machine's bearings decrease friction between moving components by restricting relative motion to only what is required. The bearing's design, for ex, might enable the moving part to freely travel in a linear direction or freely spin around a fixed axis. It may also be used to impede motion by stabilizing the vectors of the ordinary forces operating on the components that move. To provide the necessary motion, most bushings minimize friction. Bearings are classified generically depending on the kind of operation, the movements permitted, or the directions of the loads (forces) applied to the components. Rotating bearing transfer radial and axial between the originating location pf load and the framework that supports it. They maintain the position of rotating axles or shafts in mechanical systems. A shaft spinning inside a hole produces the most basic type of bearing, known as a plain bearing. Friction might potentially be decreased by lubrication. In both ball and roller bearings, rolling widgets having the shape of a circle sit across the racing elements or chambers within the gear assembly to reduce sliding friction. Because there are so many different bearing designs to choose from, it is possible to meet the requirements for performance, dependability, durability, and ideal effectiveness.

Specification-:

UCP 204 Pillow Block Ball bearing

Shaft diameter	20 mm
Center height	33.3 mm
Housing overall width	34 mm
Center distance between 2 bolt holes	95 mm
Bearing total width	31 mm

Table 3.2.6.1. Bearing dimensions

Dynamic load rating	12.7 KN
Static load rating	6.7 KN
Limiting speed	6500 rpm

Table 3.2.6.2.. Bearing Performance

3.3. Site Selection

The following sewage is located at Sambhappa Colony, Chittod Rd. Dhule. The reason for selecting the following site is that there is a slum near the locality causing plastic garbage and waste to accumulate near the sewage line. There are many animals eating the food in the garbage or plastic bags, the animals push the waste in the sewage line causing water clogging. Living near the locality we have experienced foul smell and other health issues closely. There is a public toilet located near the sewage line, in case of water clogging there is a problem of unpleasant odor.

Figure 3.3.1.. Selected Sewage Line

Figure 3.3.2. Waste near the sewage line

3.4. Mechanism & working model developed

The automatic sewage cleaner uses a chain drive mechanism to make it work. There are two shafts, one at the bottom of the machine and the other at the top of the machine. The shafts relate to a sprocket at each end of it, so the machine uses a total of four sprockets and two chains connected on the sprockets. The sprockets are made rigid to the shaft with the help of key, the key keeps the sprocket connected to the shaft without the shaft and sprocket moving separately. The chain has two lifter mounts that are connected to it through chain links. The shafts are inserted in the pillow block ball bearing which is fixed to the frame with the help of nut and bolts. The upper shaft is connected to an DC motor with the same principle of key and hole. The frame has a detachable bin flexibly mounted at the back; the bin can be easily removed by the help of hooks attached to it.

Figure 3.4.1. Mechanism developed

The machine is inserted inside of the sewage line and the motor is connected to a batter or an adapted to supply an AC supply. The motor starts rotation which rotates the shaft which is connected to it. The sprocket which is over the shaft starts rotating to which the chain is connected. The chain is connected on the sprocket located at the lower as well as the higher shaft. The chain link links the lifter mount to the chain, this causes the lifter mount to revolve over the chain. As the water passes through the sewage line, it flows through the net connected to the machine's frame. Water flows through the net while any waste material gets picked up by the lifter mount continuously rotating with the chain. The bin is set at a distance where the lifter will mount the waste in it. The collection can be easily removed, and the waste can be managed easily and in a more ethical way.

Figure 3.4.2. Lifter mount and bin

4. MATERIAL SELECTION AND FINALIZATION

For the main frame square pipes which are of mild steel have been used, the pipes are cut by cutter and joined together by welding process. In this case arc welding is done to join the frame parts. Arc welding is a sort of metal joining procedure that generates heat using an electric arc. Direct (DC) or alternating (AC) currents are used by a power source to generate an electric arc between a base material and a consumable or non-consumable electrode. Metals are joined together using this heat. A solid welded joint is created when the arc is brought in contact with two metal parts, melting the metal due to the heat produced. Electric current—the power source utilized in arc welding—is electricity. Direct current (DC) or alternating current (AC) electric currents may be employed. When the arc meets two metal components and melts the metal because of the heat produced, a solid welded junction is formed. Arc welding uses electricity as its power source, which is electric current. Electric currents may be generated using either direct current (DC) or alternating current (AC).
For shaft cutting, facing, and drilling operations are done. The shaft is cut into required size of 16.5 inches and 15.5 inches. Facing is done to finish the uneven face of the shaft, drilling to drill hole for key slot where the sprocket will be fixed to the shaft.
For sprocket, the internal diameter of the sprocket is made to 20 mm from 15 mm as the shaft diameter is 20 mm. Drilling is performed the insertion of key slot to it so it can be rigidly fixed to the shaft.
The bearings have been mounted on the main frame with nut and bolt. The collection bin also uses nuts and bolts for its assembly. The motor has been mounted to the frame with a steel plate welded to the main frame and nut bolted.

S. N	Component	Material	Manufacturing process \ operation
1	Frame	Steel	Welding
2	Motor	Steel	Welding and Nut-bolt
3	Shaft	Mild steel	Cutting, Facing, Drilling
4	Sprocket	Mild steel	Boring, Drilling
5	Collection Bin	Metal sheet	Welding, Drilling

Table .4.1.Material Selection

5. RESULTS AND DISCUSSION

5.1 Results of the physical tests performed
Various tests were carried out on and off the selected site which showed the following results and observations.
5.1.1 Test on collection bin
Tests were carried out on the bin to test the amount of weight it can carry. The tests were performed off the working site, the use of construction brick was made to check the amount of weight the bin can easily withstand. Each brick weighs around 3 kgs. The collection bin can easily withstand 15 kgs of weight and on any untimed occasion even more. Another test at the working site shows that the use of net at the bottom of the bin instead of a completely packed solid base performed optimally. As the waste is lifted by the lifter mount, with the wastewater is also carried in some amount, as the waste falls in the collection bin the water drips away through the net. If there is no net provided the problem of stagnant water will appear inside of the collection bin.

Figure 5.1.1. Weight carried by collection bin

5.1.2 Tests on the lifter mount
Tests on lifter mount were made on and off the working site. These tests included the amount of weight a lifter mount can successfully lift without stopping the mechanism. This test was also made with the help of a construction brick as a form of weighted object. The test showed that the lifter mount and the mechanism could easily lift a brick weighing around 3 kg without any mechanical failure of the lifter mount and the mechanism itself as well. The use of two lifter mounts will help in the events of rainfall and flooding in the sewage as 1 lifter mount will not be enough to lift the extra amount of waste flowing in such conditions. The lifter mount is connected to the chain

with chain link which showed good coordination with both the chains on each side.

Figure 5.1.2. Weight carried by lifter mount

6.1.2 Tests on working site

Figure 5.1.3. Model at the working site

The fitment of the model inside the sewage line followed by the actual testing and running of the model inside the sewage at the working site showed that the model runs effectively inside the sewage line and performs its given task optimally and effectively. The lifter mount collects the garbage flowing at the upper level and a support given at the front of the model raises the garbage level even further. The net attached to the frame works effectively by allowing the flow of water and restricting the solid garbage passing through it.

6. CONCLUSION

The widespread issue of waterlogging in various localities poses a significant and lethal concern, necessitating attention and a solution. The design of an automatic sewage cleaner carefully considers factors such as garbage collection capacity, lifter mount weight tolerance, motor specifications, and component requirements. Fabrication utilizes square pipes to reinforce the frame's stability within sewage environments.

Efficient sewage line cleaning is of paramount importance for public health protection. Untreated sewage can harbor harmful bacteria, viruses, parasites, and pathogens like cholera, typhoid, hepatitis, and gastroenteritis. Effective sewage waste management is imperative to mitigate the transmission of these diseases and safeguard public health. Inadequate sewage waste management can lead to severe environmental consequences. Discharging untreated sewage into water bodies can result in water pollution, with high nutrient levels promoting eutrophication, depleting oxygen, and causing harm to aquatic ecosystems.

Proper sewage waste management, including treatment and safe disposal, is essential to preserve water quality and protect the environment. Many communities depend on surface or groundwater as their drinking water source. Ineffectively managed sewage waste can contaminate these water sources, compromising the safety of the drinking water supply. The use of automatic sewage cleaning machines effectively addresses issues such as waterlogging, improper sewage waste management, hazardous manual sewer cleaning practices, delayed sewage maintenance, and foul odors.

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