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Automated Scavenging System with Hybrid Bins and Filters

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Abstract: India is considered to be the second – largest in terms of population and one of the countries in mass production of waste. Even though many steps were taken to manage waste but none provide a solution to manual scavenging and segregation. Moreover, ditch line cleaning is a major part of sanitation work. Manual scavenging is a potential health threat to sanitation workers 69% of street sweepers & scavengers suffers from multiple health problems. Manual scavenging is not only harmful it is physically exhaustive too. Manual scavenging is harmful and disrespectful practice but it is required to keep our city clean. Another major threat is global warming and climate change. The most suitable way to recover our mother earth is to increase in growth of trees and plants at a massive rate. Management of saplings in cites is one of the major drawbacks and cost is arithmetically higher in rate. Thus we intend to provide a more appropriate solution to manual scavenging, ditch sludge clearance and sapling management in roadsides with hybrid bins. An automated vehicle is used to collect and segregate the solid waste in the roadside with the help of mechanical structures, actuators, and a vacuum pump. A movable filter is used in ditch lines to collect sludge, slurries, plastic waste and other floating matters. A hybrid bin is constructed in such a way where it allows spacing to plant a sapling and an electronic stick is embedded in it to manage the growth of the saplings in all aspects. Thus through our innovation, we provide scavenging at a faster rate, increase the dignity of workers, reduce they're prone to health hazard, reconstruct the climate change and make a better place to live in.

Keywords: Scavenging, Waste Collection, Urban Forest.

I. INTRODUCTION

India is the second most populated country in the world after China. The population of India is projected close to 1.37 billion or 1,369 million in 2019, compare to 1.354 billion in 2018. The population growth rate for 2019 is projected at 1.08%. India will add 1.49 crore in 2019. According to the Press Information Bureau, India generates 62 million tonnes of waste every year, of which less than 60% is collected and around 15% processed. With landfills ranking third in terms of greenhouse gas emissions in India, and increasing pressure from the public, the Government of India revised the Solid Waste Management after 16 years. The generated waste can be divided into three major categories: Organic (all kinds of biodegradable waste), dry (or recyclable waste) and biomedical (or sanitary and hazardous waste).

Every Indian town has at least one specific area earmarked as a landfill area. The collection process begins with contractors employed by government bodies performing door - to - door collection services covering all households, scourging for any recyclables that may fetch a market price and later transporting all remaining waste to landfills. Each truck typically waits in line for two to three hours for its turn to weigh the amount of waste collected that day and then typically waits for some more time to dump the waste into the landfill.

[6]The US Public Health Service has identified 22 human diseases that are linked to improper solid waste management (MIT Urban Development Sector Unit 1999). Several studies have been published that link asthma, heart attack, and emphysema to burning garbage. Human fecal matter is also frequently found in municipal waste. This, along with unmanaged decomposed garbage, attracts other rodents that further lead to a spread of diseases such as dengue and malaria (Biswas 2012).

As shown in Figure 1,[6] less than 60% of waste is collected from households and only 15% of urban India's waste is processed in a country 12 times as dense as that of the United States (US) (PIB 2016).

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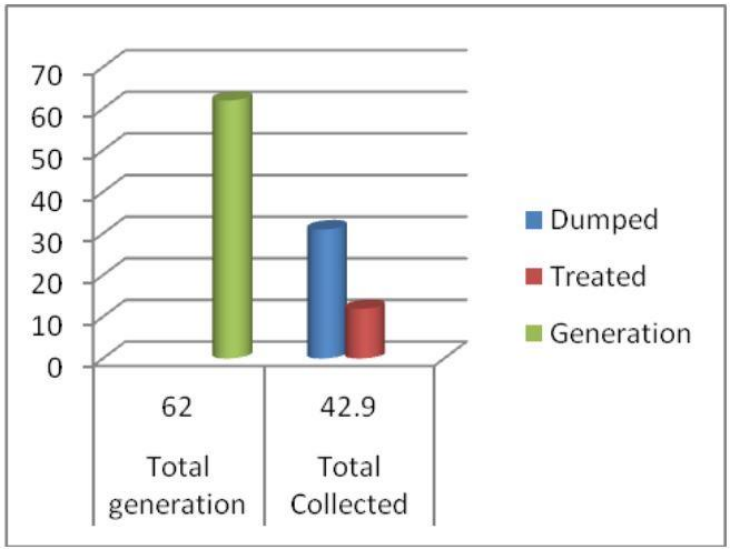

Fig 1: Collection vs. Dumped Statistics (numbers in million MT per annum) (Source: PIB, Government of India)

[9]Global warming, caused by greenhouse gas pollution, is causing immediate and direct changes to the planet. The Earth's temperature had already warmed by 1°C compared to pre-industrial levels. This temperature rise may appear small, but small rises in temperature translate into big changes for the world's climate. This is because the amount of extra energy needed to increase the world's temperature, even by a little, is vast. This extra energy is like force-feeding the global climate system.2016 was the hottest year on record, the previous record was broken in 2015, and 2020 is expected to set a new record for the third year in a row. In the past few years, records have been broken for the longest heat waves and the Bureau of Meteorology has added purple and magenta to the forecast map for temperatures up to 54° C. Increased Ocean temperatures are melting glaciers and ice caps all over the world. Melted ice increases the volume of water in our oceans. Warmer temperatures also result in the expansion of the water's mass, which causes sea levels to rise, threatening low-lying islands and coastal cities. Extreme weather events like bushfires, cyclones, droughts, and floods are becoming more frequent and more intense as a result of global warming The oceans have absorbed most of the extra heat and carbon dioxide (CO2) so far - more than the air - making the seas both warmer and more acidic. Warming waters are bleaching coral reefs and driving stronger storms. Rising ocean acidity threatens shellfish, including the tiny crustaceans without which marine food chains would collapse. [10]Figure 2 shows the history of the global temperature since 1880.

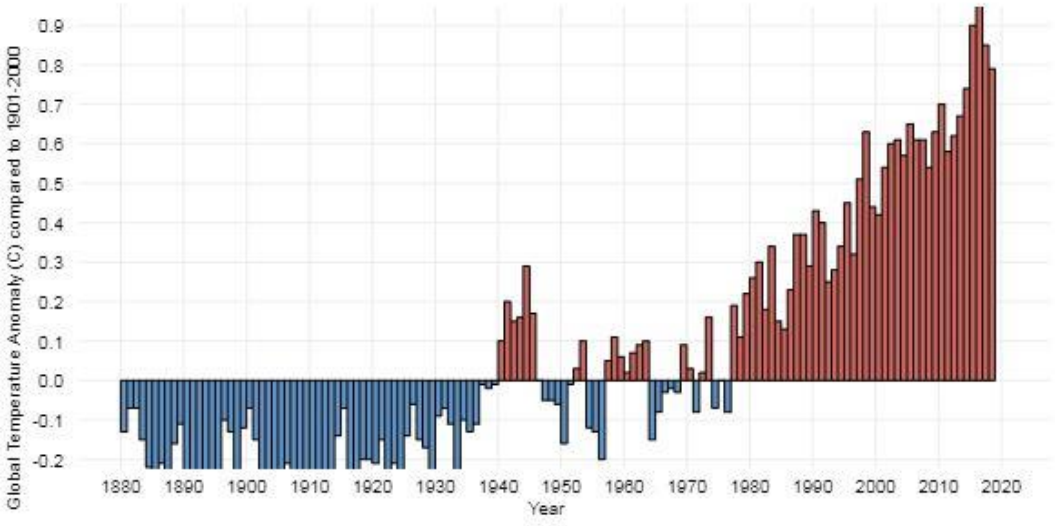

Fig 2: Graph of Global Temperature

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II. LITERATURE REVIEW

Street Sweepers: [1]The corporation sweeper suffers from severe back pain and often has breathing difficulty. A study by Madras Medical College (MMC) found that nearly 69% of the city sweepers suffer from multiple health problems. It includes disorders related to bones, joints and muscles, lungs, eyes, and skin. The researchers observed these health issues were due to prolonged exposure to dust, lack of periodic health screening and customized cleaning equipment like broomsticks and poor awareness and negligence in using safety gear. Among the 73 workers, including 49 women, profiled, women sweepers were found more prone to musculoskeletal problems, back pain is the most common complaint among the workers (70%). Improper working posture, usage of short and damaged broom and inadequate supply of brooms were the cause for an increase in the prevalence of musculoskeletal problems.

The biological materials in the dust are capable of causing allergic diseases in humans such as the runny nose, watery eyes, and sneezing by large-sized particles, as well as swelling of lung tissue and asthma by fine particles, the study said.

[7] According to a National Institute for Occupational Safety and Health study in 2008, work-related respiratory diseases account for about 70% of all occupation-related death worldwide. According to International Labour Organization, street sweepers have more than one incidence of illness with common issues being flu, cough, eye irritation, rash, skin irritation, diarrhea, stomach upset, chronic cough and eye disease. Many studies have detected morbidities among sweepers like hypertension, respiratory tract infection and chronic bronchitis.

Ditch Clogging: A clogged drain can be a serious problem. Often, people choose to ignore clogged drains, hoping that they will clear out on their own. However, ignoring a clog often leads to it becoming severe and even blocking the drain completely. A clogged drain can be inconvenient, it causes improper flow of water in roadsides ditches. It is one of the major reasons for flooding and mosquito breeding. Here are some of the effects of a clogged drain is poor drainage, dirty water, bad odours, health risks, leaks, etc.

Arboriculture in Cities: [4]Sustainable arboriculture is broad-based and complex due to the diverse and dynamic character of urban green areas and their environment owing to the impact the people and their activities have on an urban tree- e.g., planting, removal, pruning, land development, plant injury. Wide- range activities of people are among the major forces for change in the health and character of the urban forest and ultimately determine its sustainability, more so than any other forest resource. In this scenario, sustainable tree care and maintenance represent the preservation of the long term efficiency of the urban ecosystem in an environmentally conversing and safe manner coupled with economic viability, social justice and equality for the citizens. Although urban green areas have been acknowledged globally to be of utmost importance, the term “Sustainable Arboriculture" is often loosely and in a general manner as a label, brand or icon to make it acceptable to all types of stakeholders and under various environments. In the coming decades, arboriculture and urban forestry will have face many challenges as population increases and demographic changes, flinching per capita natural resources, environmental degradation, climate change, and globalization. At the international level, urban green areas are more and more perceived as vital spaces for the development of important functions as the strictly economic- environmental and the social and economic ones. Also, in many urban areas, lack of proper tending and maintenance results in much higher tree mortality rates that cannot be sustained over the long term. In this paper, we will be seeing the hybrid bins and an electronic stick to maintaining the sustainable growth of urban forest.

III. AUTOMATED SCAVENGING VEHICLE

Automated Scavenging Vehicle:

It is a system that eliminates manual scavenging in road and ditch lines with help of automated scavenging vehicle and movable hybrid filters. The scavenging vehicle is of the type of lawnmower. The vehicle is moved manually. The vehicle is constructed in a way where it collects all the solids like derbies, plastic materials, filthy materials, etc.

Structural Frame: The structural frame of the vehicle is made up of 1mm hollow square mild steel tubes with a length of 3.5 ft, width 1.5 ft and height of 3 ft. A handle is placed for the movement and control of the vehicle. The frame is made up of temporary joints using nuts and bolts. Two pairs of universal wheels are placed for the locomotion of the vehicle.

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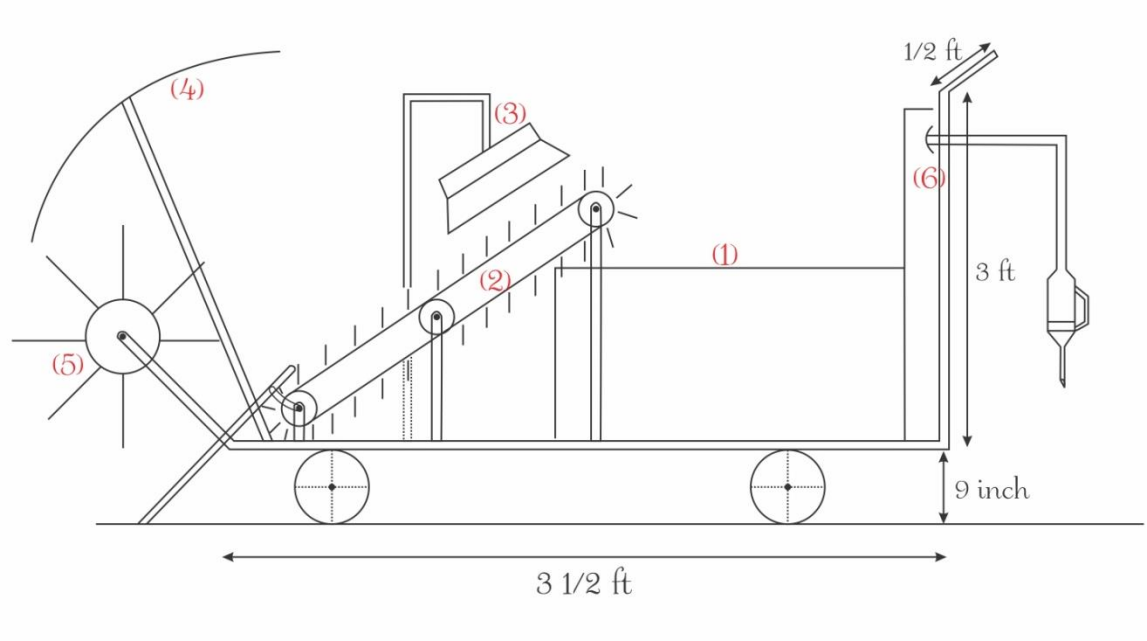

Fig 3: Schematic Sketch of Automated Scavenging Vehicle

3.1 Removable Bins Setup: A removable bin is made up of stainless steel plates. This is in the dimension of 2*1.5*2.5. It is of the length of 2 ft, the width of 1.5 ft and the height of 2.5 ft. The total volume of the bin is 7.5 cubic feet and has the capacity to hold the garbage of 212 litres. The sliding friction of the bin is relatively less thus it is easy to discharge the garbage in dump yards.

3.2 Conveyor Setup: The garbage fills which are collected in the ramp is transferred to the removable bins with the help of conveyor belts. The conveyor is made up of the stepper belt and driven by the DC motor. The motors are clamped to the structural frame with the inclination of 25 degrees. The length of the conveyor is 2 ft and a width of 1.5 ft. The conveyor belt has a capacity of carrying the load of 5 - 7 kg.

3.3 Segregation Setup: [8]An electromagnet is connected above the conveyor. This is used to separate metallic and non - metallic waste moving through the conveyor. An electromagnet is clamped to the structural frame to balance the load on it. It has the capacity to hold 6 kg of metallic waste. It is energized by 12 v rechargeable lithium batteries and controlled via switches.

3.4 Pneumatic Actuator Setup: A pneumatic actuator is connected to the structural frame. An arc - shaped sheet is mounted to the pneumatic cylinder. The angular movement of the actuator is controlled via a DC stepper motor. During the elongation of the actuator, the arm is set free at a 0-degree angle as the compression takes place thus garbage is collected and moved towards the ramp, and then the angle of the bar is set to rest position at 110 degrees. These pneumatic actuators increase efficiency by increasing the rate of garbage collection.

3.5 Ramp Setup: [3]A ramp is connected in the front section of the vehicle with the inclination of 35 degrees with a length of 6.5 inches. A rotating circular cylinder is connected with the12 v dc motor which drives the rotating cylinder. [5]The rotating cylinder is mounted on the ramp straight right angle to the center to the length of the ramp. Spikes and collecting plates are embedded in the rotating cylinder which increases the efficiency of the vehicle by collecting the garbage fills without manual interventions.

3.6 Vacuum Setup: The vacuum system is an auxiliary function part of the automated scavenging vehicle. It mainly assists in improving efficiency by collecting paper bits, micro plastics, dust, sand, and fine particles, etc. The vacuum system used an electric motor (775-12 v DC motor) to drive the fan blades to rotate at a high speed by, and negative pressure was formed in the sealed casing to absorb external dust. Therefore, there are certain requirements for the curvature and size of the blade. In this way, the fan air volume can be guaranteed to have a certain vacuuming capacity. Known wind volume calculation as in (1).

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$$Q=VF \quad (1)$$

Where V is the Wind speed, it can be accurately measured with an anemometer; Q is the air volume; F is an air duct cross-sectional area. According to the design requirements, the maximum air volume is not less than 3000m3/h.

$$Q_{max} \geq 3000m3/h \quad (2)$$

Completion of fan blade design calculation according to formula (1) and (2). [5]The outer diameter of the fan is 23.5 mm. As shown in Figure 3. The vacuum structure is made out of PVC material. It has a detachable part were the waste can be discharged and attached to the vacuuming system. It is powered by lithium batteries and controlled by switches. Figure 3 shows the schematic sketch of the vacuum blade.

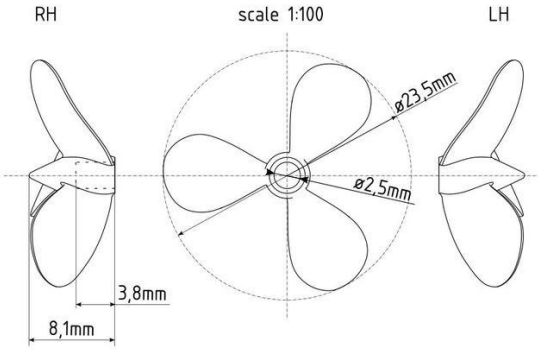

Fig 4: Vacuum Blade

Scavenging vehicle is driven manually in the streets. When there is a need to collect the garbage fills on the roadsides, the vehicle is moved towards the garbage, the roller setup collects the garbage's automatically. In addition, actuators are used to collect garbage's efficiently. The collected garbage is transferred to the removable bins via conveyor. During the line of transfer, the metallic particles are segregated with the help of an electromagnet. A vacuum is used to suck the micro plastics, dust, sand, paper bits, etc.

Thus the vehicle is constructed in an efficient manner and eliminates manual scavenging. It provides a feasible solution to the scavengers and street sweepers by reducing their workload and health hazard.

IV. HYBRID FILTERS

Hybrid filters are used to remove the sludge, slurries, floating materials, etc in the ditch lines and open drainages. It works in the rotational motion to remove debris in ditches.

The hybrid filter is placed in the ditch lines which are of in the width of 3 - 5 ft. An L-shaped mild steel mesh is fabricated in accordance with the width of the ditch lines. The base of the L - shaped is equal to the size of the removal bin which is placed behind the L - shaped filter. The filter and the bin are connected through a sheet of rubber to eliminate the leakage of debris during its rotational movement. The L - shaped filter is placed in accordance with the flow of the water in ditch lines. One end of the L - shaped filter is connected to the shaft of the AC motor.

The control of the rotation movement of the motor is placed in the scavenging vehicle with the help of RF controllers. The power supply to the hybrid filters is given through the AC supply from the street light poles. When the scavenging vehicle nears to the location of hybrid filters the signal is received from the transmitter of the scavenging vehicle of a certain frequency.

By the control action in the scavenging vehicle, hybrid filters are rotated to discharge the debris collected in the ditch lines to the removable bins the hybrid filters. Thus the ditch lines automatically scavenged without manual interventions in a feasible and efficient manner. Figure 5 shows the block diagram of the hybrid filter.

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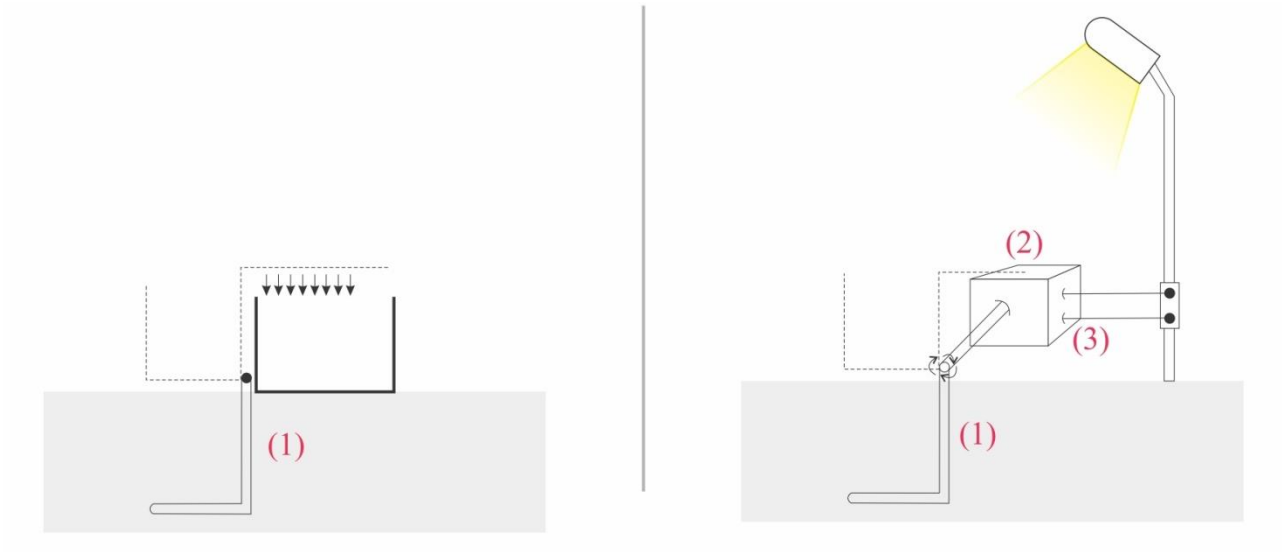

Fig 5: Schematic Sketch of Hybrid Filters

V. SMART BINS

Smart Bins are employed to increase urban forest (arboriculture) Smart bins are placed to increase urban forest. It plays major roles in collecting biodegradable and non-biodegradable waste and also gives a protective space for saplings growth. It is made up of two PVC bins of a diameter of 1.5 ft. A diameter of 2 ft of space is given in between the two bins and it is covered by a circular mesh. The bins are attached to any two sides of the circular mesh with a supporting stand. Thus it provides a hybrid feature by protecting the sampling from external damages and serves the path in waste disposal in cities. Figure 6 shows the block diagram of the smart bins.

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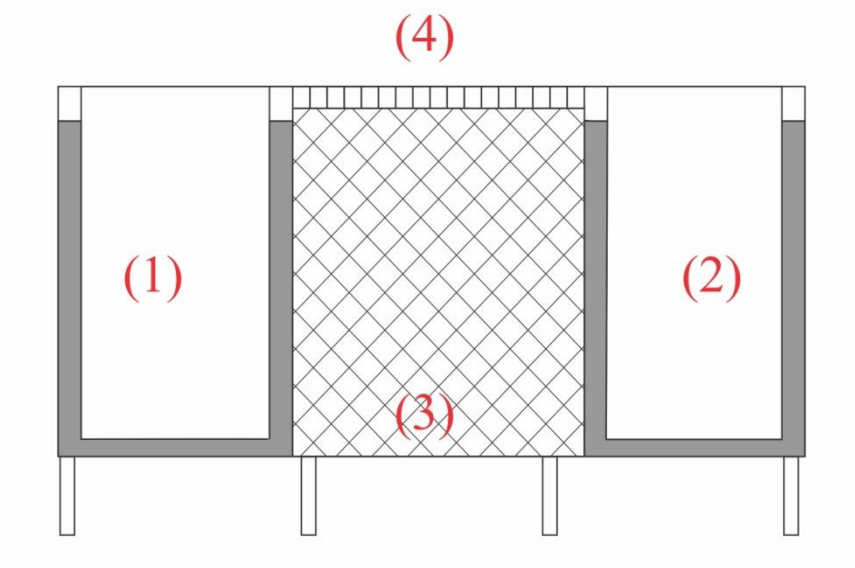

Fig 6: Schematic Sketch of Smart Bins

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VI. ELECTRONIC STICK

[2]Though arboriculture is implemented in cities the management of it serves as a tougher task. Management of sampling is a major part of arboriculture. An electronic stick is placed in the smart bins for maintenance of the sampling. It is made of PVC material. A hopper shaped tubing structure is employed where the upper section is in the diameter of 3.5 inches and gradually reduces in the size of 1.5 inches with the help of reducers. The lowermost part is carved into an inverted conical structure as it provides a path to penetrate the ground to give stability for the stick and also for the saplings. It is a hollow structure that enables water and nutrients to store for a period of time. A soil moisture sensor is embedded in the inverted conical structure which measures the moisture content in the soil. When the moisture content is below level a control signal is given to the pump which is connected to the NODMCU controller.

When the water level in the hollow structure is low, it is indicated by a level sensor through the NODMCU controller to the arboriculture managing forum in the cities (IOT concepts) to refill the stick with nutrients and water. The overall stick is powered by the solar panels mounted in the smart bins.

The solar panels give a potential difference of 12 v and 2.4 A which is sufficient to recharge the mini batteries in the electronic stick. Thus it paves a way to increase the urban forest in cities by protecting and maintaining feasibly and efficiently. Figure 8 shows the block diagram of the electronic stick.

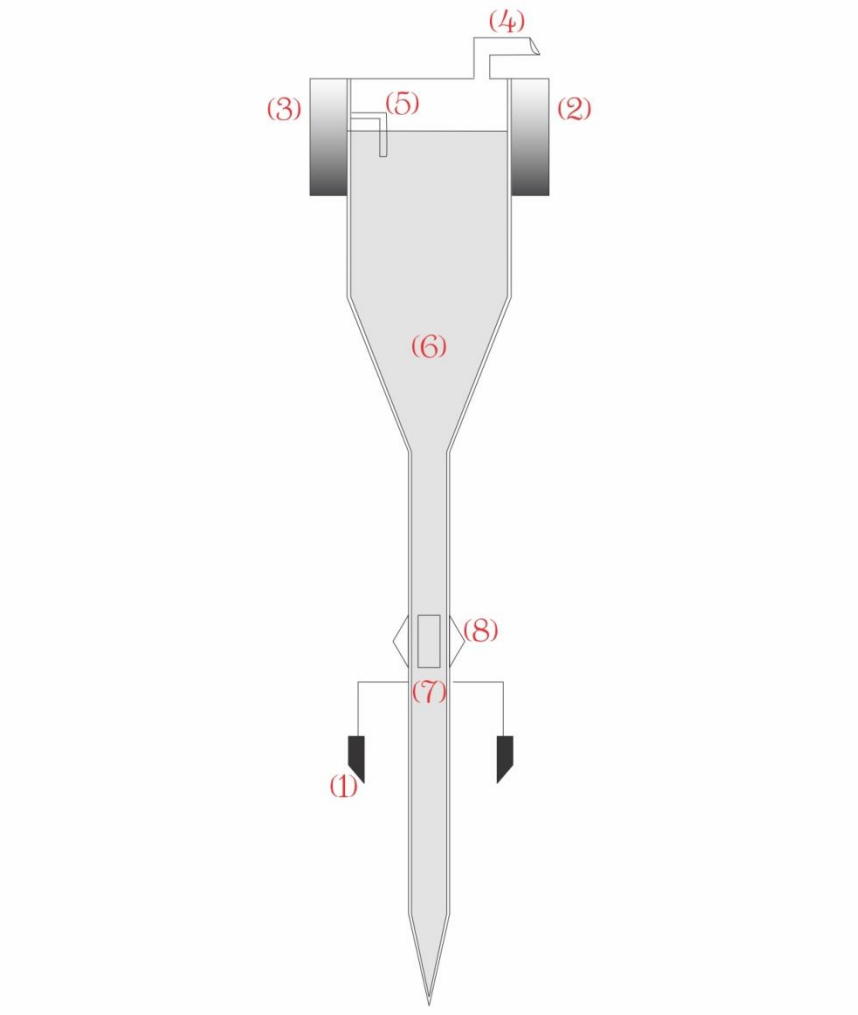

Fig 7: Schematic Sketch of Electronic Stick.

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VII. REAL TIME PROJECT RESULTS

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VIII. CONCLUSION

Though various technologies like IoT (Internet of Things), image processing, pick and place and computer vision are employed in the scavenging process, none provide a feasible output. Even though it provides a feasible outcome, the cost is relatively high. The practical implementation of these technologies is complex. The system which is explained in this paper breakthrough all the gateways in automating scavenging system. It is cost-efficient. It eliminates all practical issues in the field and provides a long term maintenance-free system.

Thus the professional dignity of the scavengers are recovered which has been a major issue for decades. Their social status is increased, health issues and their workload is decreased. This system provides a sustainable future for the upcoming generation by eliminating carbon footprints, reducing global warming and restores climate change of mother earth.

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BIOGRAPHY

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