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Automated Waste Disposal system using Sludge Vacuum Pump

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***Abstract* - Waste disposal is one of the lifecycle phases that influence the environmental sustainability of waste management. At present door-to-door collection, recycling and land-filling disposal system was being followed. To overcome the drawbacks in the existing system an automated waste disposal system was developed. This system has sludge vacuum pump placed in garbage truck and the inlet of sludge vacuum pump is connected to the waste collection tank of garbage truck. When the truck parks on the parking lane, waste get sucked from the waste bin through sludge vacuum pump and deliver this waste to waste collection tank of garbage truck. This system speeds up the whole collection and disposal process. As this system reduce the man power, improve overall safety, rectifies the hygiene issues and efficiency shortfalls in waste collection.**

Keywords - Land filling, Sludge vacuum pump, Garbage truck, Waste bin

1. INTRODUCTION

The steps for managing the waste collected from its point of generation to its point of decomposition include several processes like collection, transportation, treatment, and disposal of waste. The expanded sum or employments of plastics and the employments of solidified nourishments which is useful to lessen the amounts of food squanders in the home however increment the amounts of waste at rural handling units. Hence, directly or indirectly every person creates waste in the form of agriculture wastes, mineral wastes, industrial wastes, medicinal wastes, and also residential waste in the society. That is the reason the decay of a wide range of these previously mentioned strong waste has become significant issues for the administration of various nations on the planet since it makes ecological issues and natural contamination. Squander isn't in the single structure it very well may be strong, fluid, or gas and each type has various strategies for removal and the executives. Squander the board framework manages a wide range of waste, including modern, organic, and family unit squanders. At times, waste can likewise be risky to human wellbeing.

Pneumatic waste collection system represents a new way of arranging waste collection in densely populated urban areas. The development of underground infrastructures for the efficient management and collection of urban waste streams offers great advantages and solutions in tackling problems relating to these activities [1]. Separated collection is an important part of waste management, because it allows material recovery. In order to organize separate collection operations, complex decisions need to be taken on the basis of a large amount of data. The problem of planning the door-to-door waste collection of multiple materials for a municipality is considered. A multi objective optimization model is proposed, aiming at minimizing both operational costs and possible inefficiencies of the recycling logistic system causing negative environmental impacts [2]. The model is applied to a real case study and a mixed integer programming heuristic algorithm is used for its solution. Solid waste collection, segregation and disposal constitute a huge responsibility for the governmental municipality. If the municipal authority does not have good waste management system for its disposal, it may create environmental and social problems. To avoid such problems and to improve the cleaning, a system of automatic collection and segregation of domestic solid waste is proposed [3]. A domestic waste collector which makes use of the technologies like sensors, IOT and Cloud Storage for efficient solid waste management had been used. The system further segregates collected waste on the basis of density of solid waste material. This will help to reduce the overflow of the garbage bin, smooth data collection and reduces the manual segregation efforts to keep environment clean. the Waste Management through Smart bin system that looks for the amount of waste in the bin. Dustbin containers are used for collecting the household as well as human society waste from all around the world. This system is designed such that it continuously collects real-time data to maximize the operational time and deliver this data through a wireless mesh network. The Smart- bin system was tested in an outdoor environment. The collected data from the dustbin was applied with sense-making methods to obtain refined utilization of our smart bin. It also gives the daily seasonality information to theMunicipal Corporation which enables them to make better & organized collection for recyclable, organic, and plastic waste [4].

Bengaluru city has identified many disposal sites for the scientific disposal of municipal solid waste generated in its jurisdiction. On an average, 5000tons of municipal solid waste is generated per day. Since source segregation is not done by the people, not strictly made mandatory by the authorities, and no proper logistics arrangement for the separate collection of different kinds of municipal solid waste, mixed waste is reaching the processing/landfill sites, thereby seriously affecting the efficiency of processing plants, and about 23.5lakh tons of mixed solid waste indiscriminately dumped at supposedly called processing and landfill sites, leading to the early closure of many landfill/processing plants. The present collection system in connection with the status of the waste processing/landfill site and also reviews and the effect of the existing processing /landfill sites on the environmental attributes were discussed [5]. The current state-of-the-art systems analysis techniques for urban solid waste collection and identify four intrinsic deficiencies of the existing studies over different types of cities. As a demonstration, a multi constrained and multi compartment routing problem is modelled with roll-on roll-off scheduling strategies in a two-stage decision-making process to exhibit the highest complexity of its kind in practical implementation. The constraints of time windows, intermediate facilities, multi shifts, and split deliveries make an ideal combination of all essential complexities in modelling practices. To overcome the relevant challenges, a unified heuristic algorithm is proposed for addressing node routing and roll-on roll-off routing problems. The proposed heuristic algorithm that concatenates initialization and improvement phases solves the models with numerical efficiency to search for the most cost-effective and environmentally benign solutions. Results indicate that differentiated collection increases opportunities to pursue the best routing strategies with sustainable implications through sensitivity analysis at the expense of higher collection costs [6]. The analysis concludes with the perspectives of a smart and green waste collection system designed to create a more sustainable waste management systems in the future. In most of the Indian cities management of MSW is very poor and unscientific.

The present scenario of MSW management in Agra city (India) was observed that MSW management was improper and unsustainable. Population of city is more than 15 lakh and per capita waste generation is approximately 490 gm per capita per day. Door to door waste collection is being done by Agra municipal corporation. All collected waste is being dump on an open ground without segregation. There are many inadequacies in the current practices followed for the management of solid waste. The use of modern technology, skilled manpower, design of sanitary landfill for proper management of MSW was discussed. Proper management of waste is essential for sustainable development and improvement of surrounding environment [7]. Apart from all the other challenges put forward by the existence of SARS-CoV-2, there is a need of proper management to handle the different types of solid waste especially Biomedical waste (BMW) emerging from different health care facilities, quarantine homes, and centers, that is appearing in a huge amount every day and the possible challenges we are facing while confronting the problem of this waste, that could be a source itself to spread this contagious virus, if not handled and treated properly.The susceptibility of the virus due to Biomedical waste produced daily as a result of curing infected patients had put across the challenges and the solution to handle this waste in India before it is disposed of in a more efficient method of waste handling [8].

The objective of the present work was to develop efficient waste disposal system to overcome the problems faced in conventional systems with a minimum effort and operated by a semi- skilled labor.

II. MATERIALS AND METHODS

2.1 Sludge vacuum pump

Sludge vacuum pump, also named as solids transfer pump is a type of pneumatic pump that sucks the material with vacuum produced by air operation, and then converts to positive pressure for discharging. It is a pneumatic slurry transfer vacuum pump for liquid, slurry, and solids transfer (Figure 1). Since it’s a high vacuum loading solids transfer pump, so it can be used at tough environmental for solids or sludge transfer with high working performance and less maintenance. The pump can transfer material with high gravity and high density, with dry solids material or slurry with solids content maximum up to 80%. The specification of the pump was given in Table 1.

Sludge Vacuum Pump

Table -1

Specifications of the Vacuum Pump

Model	GNSP-40B
Max capacity	40 m^3/hr
Inlet / outlet size	12 inch
Vacuum degree	85 Kpa
Max suction distance	50m
Max discharge distance	1000m
Max solid size	300mm
Pressure request	550Kpa – 785Kpa
Air demand	17m^3/min
Weight	892Kg

2.2 Waste Bin

Bins are installed in the ground vertically, where only around 40% of the container is located above the ground level and the rest are placed under the ground. By installation of these variety of bins may result in additional floor space. The bin is made of steel, as it has main strength as its durability (Figure 2). They can take a beating in all kinds of weather and hold a high volume of trash. In some cases, steel is the only material strong enough to contain the type of waste being dumped such as construction debris. These are capable of collecting papers, clothes, residues, municipal solid wastes etc. As this bin has large space to collect domestic wastes. And it has the hole at the bottom to empty the wastes to the truck body with the help of a pipe.

Figure 2.
Waste Bin

2.3 Underground Garbage Container

The waste and rubbish are collected underground. By installation of our containers, you will be able to use the collection point space better and simultaneously improve its aesthetic and tidiness. They are suitable for collecting papers, plastic, domestic wastes, commercial wastes and residual mixed municipal waste (Figure 3). Appropriate applications can also found in areas with longer collection distances, as large capacity allows for an extension of the loading interval and a reduction of cost in transport. Emptying 1 container may take 6-7 minutes at an average. The container complies to all safety regulations that apply to them. All materials are chosen with appropriate quality and durability.

Figure 3.
Underground Garbage Container

2.4 Plastic Reinforced underground pipe

We can use either Reinforced concrete or plastic pipes. The features of the pipe have many beneficial characteristics. It comes up with low weight at high mechanical strength, resistance against chemicals and corrosion, thermal effects (Figure 4). It can be customized as fire-retardant by using non-flammable resins. Reinforced plastic is a composite material that consists of a polymer matrix. This usually is an epoxy, vinyl ester or polyester. This pipe is a kind of thermosetting plastic. This resin brings the environmental and chemical resistance to the product.

Figure 4.
Plastic Reinforced underground pipe

2.5 Waste Collection

The wastes are collected in the bin which is situated under the ground. The bottom of the bin is connected by the underground pipe which has its outlet above the ground. When the garbage truck park on its parking lane, the outlet of the underground pipe is connected to inlet of the sludge pump through external pipe and outlet of the sludge pump is connected to waste collecting container. Then the waste is sucked by the pump and it is directly transferred to the waste collecting container.

III. RESULTS AND DISCUSSION

3.1 Evacuation Time

Evacuation time is the time required to evacuate the system from initial pressure P1 to a final pressure P2. The evacuated time can be calculated from Equation (1).

$$T = \left(\frac{V}{S}\right) log \left(\frac{P1}{P2}\right) \quad (1)$$

Where,
T is Evacuation Time (min)
V is Volume of the Chamber (m^3)
S is Pumping Speed (m^3/hr)
P_1 is Initial Pressure (bar)
P_2 is Final Pressure (bar)

3.2 Pumping Speed

Pumping speed is the ratio of the throughput of a given gas to the partial pressure of that gas at a specific point near the inlet port of the pump. It is the volume of air (at any pressure) that is removed from the system by the pump in unit time. Pumping speed is given by the Equation(2).

$$S = \left(\frac{V}{T}\right) log \left(\frac{P1}{P2}\right) \quad (2)$$

Where,
S is Pumping Speed (m^3/hr)
T is Evacuation Time (min)
V is Volume of the Chamber (m^3)
P_1 is Initial Pressure (bar)
P is Final Pressure (bar)

3.3 Suction Force

Pressure than is available in the surrounding. Suction force is given by following Equation (3)

$$F = P * A \quad (3)$$

Where,
F is Suction Force (N)

P is Atmospheric Pressure (pa)
A is Area (m^2)

3.4 Plastic Reinforced underground pipe

Air changes per hour, abbreviated ACPH or ACH, or air change rate is a measure of the air volume added to or removed from a space in one hour, divided by the volume of the space. ACH is given by following Equation (4).

$$ACH = \left(\frac{CFM*60}{A*H}\right) \quad (4)$$

Where,
ACH is Air Changes Per Hour (times)
CFM is Cubic Feet Per Minute
A is Area (m^2)
H is Height (m)

3.5 Suction Pressure

Suction pressure is a negative difference in pressure generated between two points which draws a gas or a liquid from a higher to a lower pressure state. Suction pressure is given by following Equation (5).

$$Psuction = (Pbarometric - Pvacuum) \quad (5)$$

Where,
$P_s$is Suction Pressure (Kpa)
P_b is Barometric Pressure (Kpa)
P_v is Vacuum Pressure (Kpa)

3.6 Suction Pressure

Volume flow rate (Q), also referred to as capacity, is the volume of solids that travels through the pump in a given time. It defines the rate at which a pump can push solid through the system. Volume flow rate is given by following Equation (6).

$$Q = \left(\frac{V}{T}\right) \quad (6)$$

Where,
Q is Volume Flow Rate (m^3/hr)
V is Volume (m^3)
T is Evacuation Time (hr)

IV.CONCLUSION

Due to the increase in global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. Today by using a hydraulic lift type waste disposal system during the collection of waste, some may left behind the bin which will leads to hygiene issues, which was rectified by using a sludge vacuum pump. In this present work we evacuation time of 6.55 minutes per bin with zero leakage and volume flow rate of 45.06 m^3/hr was achieved. This increased the efficiency of the disposal system and overcome the shortfall of conventional waste disposal system. It also helps in the reduction of hazardous diseases caused by pollution, reduce the man power and rectifies the hygiene issues.

REFERENCES

[1] S.Dixit, D.Rastogi, “Underground Automated Vacuum Waste Collection System”, International Journal of Engineering Technology, Management and Applied Sciences, vol. 4, no. 5, 2016.

[2] D. Anghinolfi, M. Paolucci and M. Robba, "Optimal Planning of Door-to-Door Multiple Materials Separated Waste Collection," in IEEE Transactions on Automation Science and Engineering, vol. 13, no. 4, pp. 1448-1457, Oct. 2016, doi: 10.1109/TASE.2016.2599517

[3] Ompriya Kale, Sonali Lunawat, Madhuri Badole, “Automatic Collection and Segregation of Domestic Solid Waste using IoT”, IJAST, vol. 29, no. 08, pp. 2259 - 2266, 2020.

[4] Shubham Rai , Nipun Goyal, 2020, Waste Management Through Smart Bin, International Journal Of Engineering Research & Technology (IJERT), vol. 09, no. 09, 2020.

[5] Pavan, H. B. Balakrishna. “Municipal Solid Waste Collection and Disposal in Bengaluru City”, International Journal of Engineering Research &Technology(IJERT), vol. 03, no. 07, pp. 137-141, 2014.

[6] J. Lu, N. Chang, L. Liao and M. Liao, "Smart and Green Urban Solid Waste Collection Systems: Advances, Challenges, and Perspectives," in IEEE Systems Journal, vol. 11, no. 4, pp. 2804-2817, 2017, doi: 10.1109/JSYST.2015.2469544.

[7] Raisul Islam, “Municipal Solid Waste Management in Agra, India”, International Journal of Advanced Science and Technology, vol. 29, no. 04, 5990 – 5995, 2020.

[8] MohdFaizan, “Solid Waste Management in IndiaUnder COVID19 Pandemic: Challenges and Solutions”, International Journal of Waste resources, vol. 11, no. 04, 2020.