To Study and Analyze the Short-Term Stability of Landfill Cover by Segregating Organic and Inorganic Waste

[1]Tushar gaur, [2]Sparsh Agarwal, [3]Anupam Kumar Singh, [4]Ashish kumar kashyap
Amity University Noida, Uttar Pradesh, India
[1]Tushargaur2014@gmail.com, [2]idagarwalsparsh@gmail.com,
[3]ankur20111999@gmail.com

Abstract— In a growing country like India managing municipal solid waste (MSW) is the next emerging challenge for its government. In Delhi, there are mainly 3 landfill sites that had already reached their capacity in 2008. As of 2021 Delhi produces 11144 Tonnes of MSW per day. There is much need to segregate the solid waste coming to landfill because when a landfill site has served its purpose it needs to be closed and a liner is used to cover it up, But the organic matter present in the landfill cover starts to create a problem when it starts to decompose hence leaving behind a hollow space in landfill cover and eventually it may collapse hence there is a need to separate organic and inorganic waste to increase the stability of landfill cover. This paper proposes an automated waste segregator (AWS). MSW will be first going under the process of screening where medium sizes, fine and oversized waste particles are segregated. Then the selected waste type will go through an aeration process where its moisture content will be reduced, then it will go through a conveyor belt to a magnetic separation chamber where the ferrous waste will be sorted out. Then it will pass through an eddy current separator from which nonferrous metal waste such as aluminum, copper, etc will be separated. At last moisture sensor with the help of Arduino will segregate organic and dry waste.

Index Terms—MSW, automated waste segregator, landfill cover, organic matter

I. INTRODUCTION

In India, about 60 million tonnes of garbage is being produced every year. Ten million tonnes of waste is produced in metropolitan cities [1]. The landfills of most of these cities are overflowing with no space for fresh garbage waste [2]. The idea of "waste management hierarchy" has been embraced by the majority of nations as the step for improving municipal solid waste (MSW) management policies [3]. The organic matter present in a landfill site is responsible for a lot of problems which is adversely affecting our environment. Landfills not only occupy a lot of space but also cause many problems such as air pollution, groundwater pollution due to the formation of leachate in the rainy season, land and soil pollution, rodents nuisance, and many more. But if we observe the main cause of pollution comes out due to organic waste present in the landfill because when it starts degrading it emits a lot of methane gas which can also cause a fire in some parts and organic waste leads to air pollution, but mainly it affects the stability of landfill cover due to its degradation [4]. As organic waste can be decomposed and can be used further to generate methane gas or can be used to produce

fertilizers thus there is a need to separate organic waste from MSW. Metals can also be recycled and reused again by melting, hence we'll separate metals first from the MSW [6].

The landfill cover acts as a seal to the compacted trash and stops rodents together with rats, mice, and other animals including birds and flying insects from entering into the landfill, but mainly it stops rainwater to enter the landfill. The original design consists of two unbonded nonwoven geotextiles, a 0.5-mm thick polyvinyl chloride (PVC) geomembrane, and a single-sided drainage composite. The single-sided drainage composite was a geonet with a nonwoven geotextile heat up bonded to the top side of the geonet. A dual-sided drainage composite is a geonet with two nonwoven geotextiles heat-attached to the top and base sides of the geonet. Mostly single-sided drainage composite was used with an unbonded geotextile beneath the geonet and not a dual-sided drainage composite [5]. It is a very hectic task and requires a lot of money and engineering to construct landfill cover, hence to make our landfill sites safer and to reduce the cost of construction of landfill cover, it is necessary to separate organic waste from the landfill sites.

For effective separation of organic and inorganic waste separation, we'll use the automatic waste separation method [13], because manual separation is harmful to the health of the workers. In this automatic waste separation technique first, the Msw is passed through a trommel roller where screening of waste takes place oversized and fine waste is removed out from the MSW. Then with the help of a magnetic head pulley, ferrous waste from the MSW will be separated, and then with the eddy current separator nonferrous waste such as aluminum cans, brass scrap, copper scrap, etc can be separated Then it is passed through the bio drying chamber where drying of waste takes place and it plays an important role because it reduces the moisture content in the MSW. Then with the help of our sensors and Arduino, dry waste (glass, plastic, paper, etc) and wet waste (mainly organic) will be separated from the MSW

II. LANDFILL COVER INSTABILITY

The landfill final cover system is used for capping the landfill and gives a barrier between the surrounding environment and waste. It is done by using low permeable materials such as geomembrane, geotextile, local soil, etc. If all these elements are not assigned properly then it will affect the stability of landfill cover [5]. There are many types of landfill cover failure problems such as topsoil collapse, subsoil pipping failure, etc but here we'll discuss failure due to organic waste. Organic waste present beneath the landfill cover is responsible for providing all these protective layers on landfill cover because when it starts degrading it will emit methane gas which is 30 times more effective than greenhouse gas c02. Landfill cover also provides a barrier from mixing rainwater to MSW and prevents leachate formation by providing a good drainage system by which rainwater runoff easily [5]. The presence of organic waste inside MSW brings a lot of problems such as odor, leachate formation, air, and land pollution. When the organic waste present inside the landfill cover undergoes anaerobic decomposition then the volume of the waste starts to reduce which will create voids beneath and consequently impact the bearing capacity of the landfill cover. Therefore it is necessary to remove organic waste from the MSW to increase the stability of landfill cover.

III. DESIGN

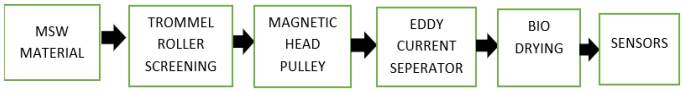

Fig 1.1 Block diagram

The block diagram shown above fig. represents the procedure of waste separation where first metals are removed from the system and then the organic matter is degraded out with the help of bio drying process, then again waste is passed through sensors where dry and organic waste is separated.

It consists of five parts:

1)Trommel roller
2)Magnetic head pulley
3)Eddy current separator
4)Bio drying
5)Sensor

A. Trommel roller

A trommel roller is a revolving screening machine that is used to screen materials of different sizes. It can be used for segregating MSW of different sizes as we do not want too big or too small sizes of waste to go under the waste segregation process. It has been observed that trommel roller efficiency increases when they are kept on at an inclination of 2 degrees instead of 4, 6, and 8 degrees [7]. As screening efficiency is directly proportional to the length of the trommel roller thus 2 degrees inclination works best for us. It is recommended that where ever it's possible the opening of the screen should be square because square size seaves are available in the laboratory too and therefore measurements performed in labs can match the field results, but off record, we use a circular aperture of equivalent square sizes [7]. As per production, there is very little difference in production cost of square and circular opening. In a research, it was found that a trommel roller with 120mm opening and it was observed that screening efficiency increases as the rotational speed of trommel roller increases thus revolving at 80 percent of its critical velocity was found to give a screening efficiency of 87 percent of its diameter and length is 3m and 10m respectively [7]. Additionally, it was also observed that a height of 2m was sufficient for breaking glass. The aperture size of 15mm is used for the removal of air classified light fraction[7].

B. Magnetic head pulley

The magnetic head pulley is a separation technique by which ferrous waste particles are separated from the MSW. This process will take place after the screening procedure in the trommel roller is done. The mixed solid waste is transported to the magnetic pulley with the help of a conveyor belt system. The ferrous particles get stuck to the conveyor belt and then removed. Rest Msw is then passed through an eddy current separator. The magnets used in the pulley to separate ferrous waste are either ceramic magnets or rare powerful earth magnets like

neodymium. Maximum magnetic induction of pulley surface is usually selected in a range of (1000-4500) [8]. This pulley comes under various sizes of different lengths, diameters, and widths. For average MSW depth of 75mm to 100mm, placed on the belt with the speed of the conveyor belt is about 2m/s for effective segregation of ferrous waste [8].

C. Eddy current seprator

Eddy current separators are used to separate nonferrous scrap from the MSW with the help of its powerful magnetic field. There are a large number of non-ferrous metals such as aluminum that still need to be separated from the MSW. Eddy current separation follows the standards of electromagnetic induction in conducting objects, to segregate non-ferrous metals by their different electric conductivities [9]. The main theory is that '*an electrical charge is generated into a conductor by alterations in magnetic flux cutting across it*'. Moving permanent magnets passing a conductor creates a change in magnetic flux [9]. The simple setup is to have the non-ferrous scrap on a conveyor belt. The conveyor pass by a spinning drum, inside of which is a much faster-spinning magnet block (up to 4000 rpm) [9]. The magnet block affects the changing magnetic flux. The scrap fragments are dropped off at the end of the conveyor with differing energies, causing separate trajectories depending on the conductivity of the fragment [9]. The most conductive fragment interact the most with the magnetic field and have the longest arches. Aluminum has the maximum conductivity for a given weight at ambient temperature than any other non-ferrous object. Non-metallic fragments such as plastic bags and paint do not cooperate with the magnetic field at all. They just fall off the bottom of the conveyor belt with no difference in energy.

D. Bio drying

Bio drying is a modern solution for the reduction of moisture content of the MSW [10]. It consists of different mechanisms such as evaporation, aerobic reactions by microorganisms, and exothermic heat which results in decreasing moisture content of MSW. Since many of the wet organic waste is wet and sticky and can be difficult to handle as they neither flow nor pour very well thus drying of this material is important to stabilize and decrease moisture content in the MSW. Bio drying also leads to volume reduction of organic waste present in MSW [10]. This process comes with benefits such as removal of odor from our MSW and it also increases the efficiency of the system. In the bio drying chamber, the biological heat is produced from the aerobic reactions of organic matter present in MSW, which reduces the moisture content of MSW. In the bio drying process, about 63 percent loss of organic mass is achieved due to aerobic decomposition of organic matter [11]. The airflow rate is kept as 40 liters per minute. It has been observed that reactor height is a very important factor affecting the efficiency of the bio drying process. In an experiment, it was observed that 167kg of MSW with 62.5 percent moisture content was passed through the bio drying chamber of height 1.65m for 10 days and after the following day, the moisture content reduced by 24.26 percent [11]. Bio drying results in a decreased volume of MSW and provides a high calorific value to MSW. The leachate and odor creation has been eliminated in the advanced bio drying reactor and that is a major accomplishment in the area of municipal solid waste management technology.

E. Sensor

Sensors are used to detect dry and organic waste further because after bio drying most of the moisture content and organic matter present inside MSW has been stabilized and most of the organic matter has been degraded too but still, there is some amount of organic waste which didn't degrade properly, that needs to be separated from the system and in the end, we are left with dry waste such as plastics, glass, paper, etc. which can be further used in landfill as they won't degrade inside a landfill and hence will not cause any stability issues in landfill cover [13].

Sensors used here to segregate are touch and a moisture sensor. The circuit will be controlled using a microcontroller called Arduino [12]. The sensors will be stuck on a horizontal plate that is connected to a servo motor [12]. When a waste particle comes on the plate sensor will detect its type, if the waste is dry then the plate will tilt left and if it is organic then the plate will tilt right and both types of waste will be easily sorted out [12]. The touch sensor is used because suppose you need to have a neutral state when there is no waste kept on the sensor. No matter how much you attempt you won't be able to reach this neutral state [12]. The moisture sensor will each time be in a dry state by default which will affect the segregator always tilting to either side. To sort out this trouble Touch Sensor is employed [12].

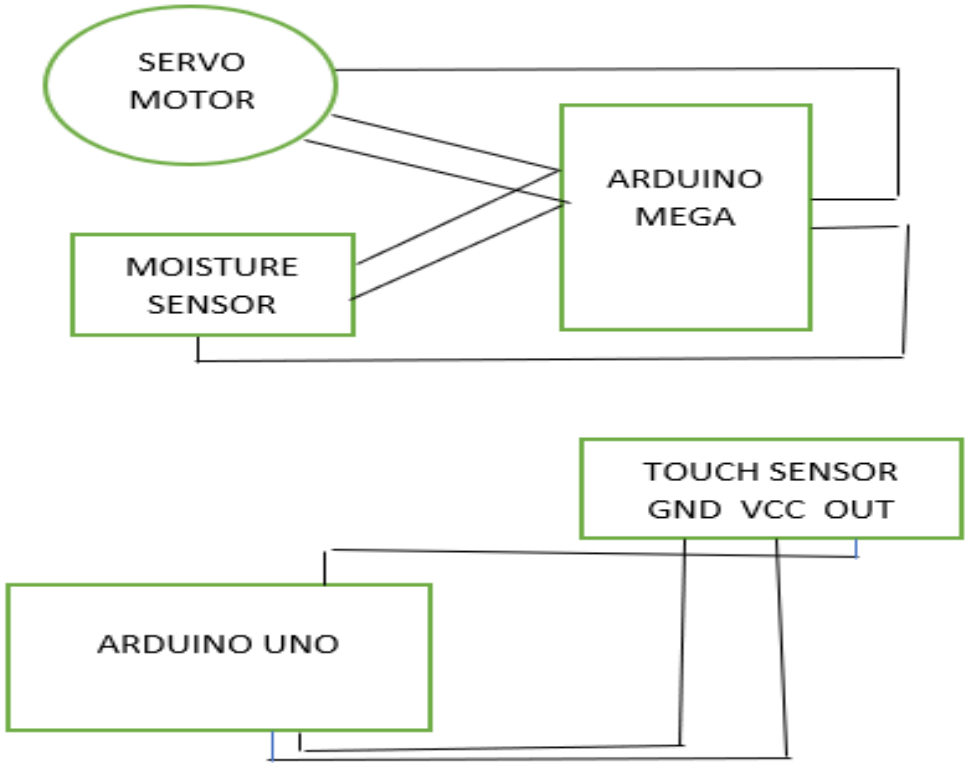

Fig 1.2 Circuit diagram for sensors

IV. FLOW DIAGRAM

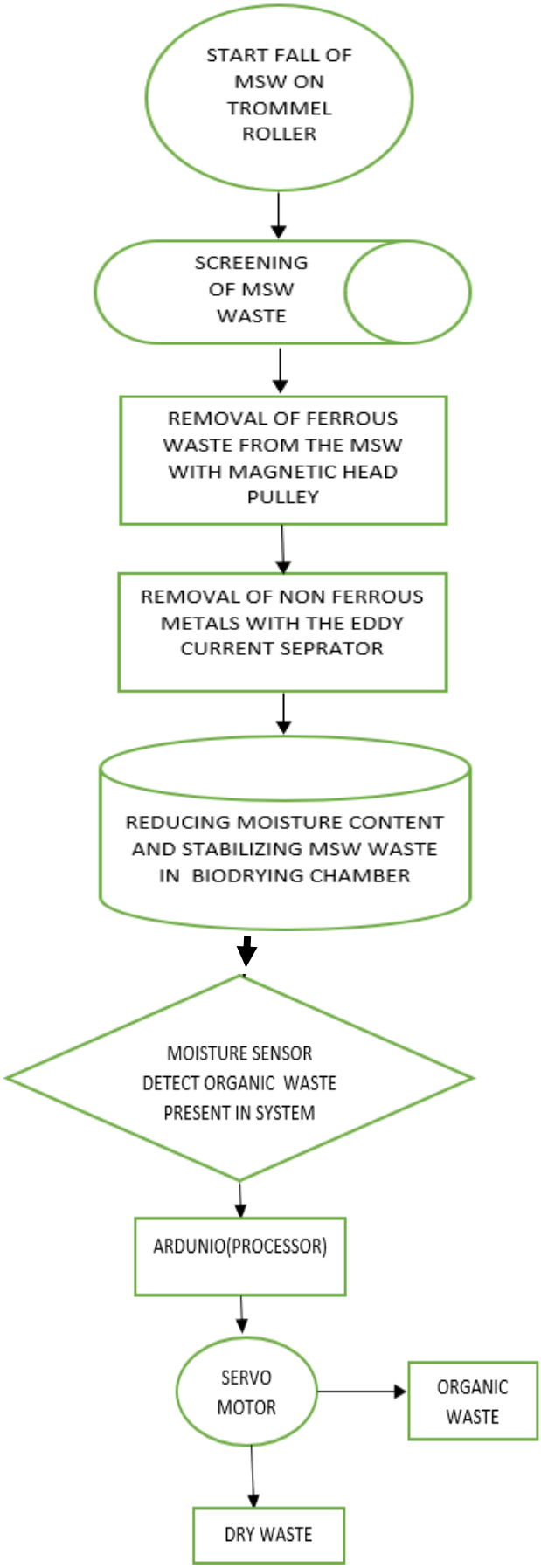

Fig 1.3 Flow diagram of automatic waste segregator

CONCLUSION

The proposed method is a cost-effective solution to the current waste managing problem which effectively separates organic and inorganic waste for landfill cover stability. This separation will lead to an increase in the bearing capacity of landfill sites and hence the space above the landfill can be used for further construction works because now there won't be any harmful gases coming out from the landfill sites. Hence no organic matter will degrade beneath landfills because there is only dry waste present beneath the landfill cover hence giving it stability.

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