DEVELOPMENT OF A SUSTAINABLE ENVIRONMENTAL PRESERVATION CENTRE (EPC) AT NAWALAPITIYA FOR URBAN SOLID WASTE MANAGEMENT

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Abstract:

An Environmental Preservation Centre (EPC) was established to resolve the solid waste management crisis of Nawalapitiya Urban Council. Material Recovery Facility (MRF), Inclined Step Grate (ISG) composting system of 5.5 tonnes/ day capacity, screening, storage and residual landfill, the total area covered by the fence including buffer zone are the major components of the EPC. After separating recyclables at the MRF, the remaining biodegradable is fed in to ISG system. Residual landfill is designed for inert materials that are remaining after the MRF and composting facility operations. MRF and ISG system are already constructed and currently initiated the operations. This is technically and financially feasible sustainable approach for protecting the environment and posterity.

Key words: *Environmental Preservation Centre, Material Recovery Facility, ISG composting unit, Residual Landfill*

1. Introduction

Nawalapitiya Urban Council (NUC) is situated in Kandy District in the Central Province home to 14,254 habitants spread over 261.3 ha of land area. Total waste generation in NUC is 12 tonnes and about 8 tonnes of waste is being collected by the NUC and directly dumped on the bank of Mahaweli River as the main disposal method until lately. It has had some influence on health, environmental, socioeconomic and political issues in detrimental ways [1, 2]. Lack of suitable and adequate lands for safe disposal of Municipal Solid Waste (MSW) has been one of the major problems. Hence, composting like landfill pre-treatment measures is an appropriate low cost management system and its application would definitely help to reduce the burden of MSW management to a certain extent while generating income and employment within the Local Authority (LA).

As a collaboration work of Japan International Cooperation Agency (JICA) with National Solid Waste Management Support Centre (NSWMSC) and Ministry of Local Government and Provincial Council, an Environmental Preservation Centre (EPC) was established to resolve this dilemma. In this effort, the vision of the UC is “to develop better and beautiful future for whole community in Nawalapitiya”. To fulfill this vision, the missions of this project are to develop a zero waste city, less waste generation rate, environmentally friendly, economically viable, socially just waste disposal methods which should be viable to treat MSW for more than twenty five years at the selected land. Thus, this paper is aimed to examine the design and development approach of the sustainable EPC at Nawalapitiya.

2. Material and Methods

2.1 Selection of the optional technical system

The reuse and recycling of wastes were the main purposes for establishing and operating an EPC. Geographical characteristics of the site, climate, wind velocities, composition of wastes, quantity of wastes, quality of wastes, aeration of composting systems, machinery used and essential services were major criteria used in selecting the best process and wastes disposal system. The total MSW collected by NUC has a high content of perishable organic matter of around 49 % by wet weight with a moderate amount of garden waste (20 %) and paper (18 %), and low content of plastic, metal and glass. Hence, around 5.5 tons of waste could be used for composting per day [3]. To design the components of the EPC, the types and composition of wastes were considered. Also to increase the efficiency, adequate space was provided both manual and mechanical operations. Double handling was reduced too.

Safety and other factors that are needed for the workers were considered for their well being such as rest rooms, toilets, dinning (away from the waste processing area) and office space. In addition, uninterrupted water and electricity supply was ensured. Besides, landscaping of the environment guarantees agreeable and pleasing visual environs for the workers as well as reduced environmental impacts beyond the perimeter of EPC.

2.2 Site selection

The selected project site of 2.02 ha is located 5 km from the town which is ideal in considering social and other environmental aspects. All of these aspects were considered in conducting feasibility and IEE studies [3, 4]. Out of which 0.8331 ha has been selected as the EPC demarcations.

2.3 Components of the EPC

By considering all the factors, Material Recovery Facility (MRF), Inclined Step Grate (ISG) composting system of 5.5 tonnes/ day capacity, screening, storage, residual landfill and fencing of the total area, including buffer zone was selected as the major components of the EPC. The layout plan of the EPC is given in Figure 1. The land was developed considering all of the constructions, including the road network. The storm water drains were constructed first followed by cut and fill of the site and then the road network, including the side drains of the roads as indicated in Figure 1. The infrastructure facilities such as site office, workers rest room and sanitary facilities, screening & storage facility, maturing facility, security room, site services and fencing were constructed parallel to other major construction activities. MRF and ISG system are already constructed and currently initiated the operations.

Trees were planted within 4 m distance from the fence as buffer while, 2 m wide buffer was established for the front of the facility as a visual barrier. The total area covered by the buffer zone is 1306 m^2. In the front, some of the flowering trees were planted to give additional value to frontage.

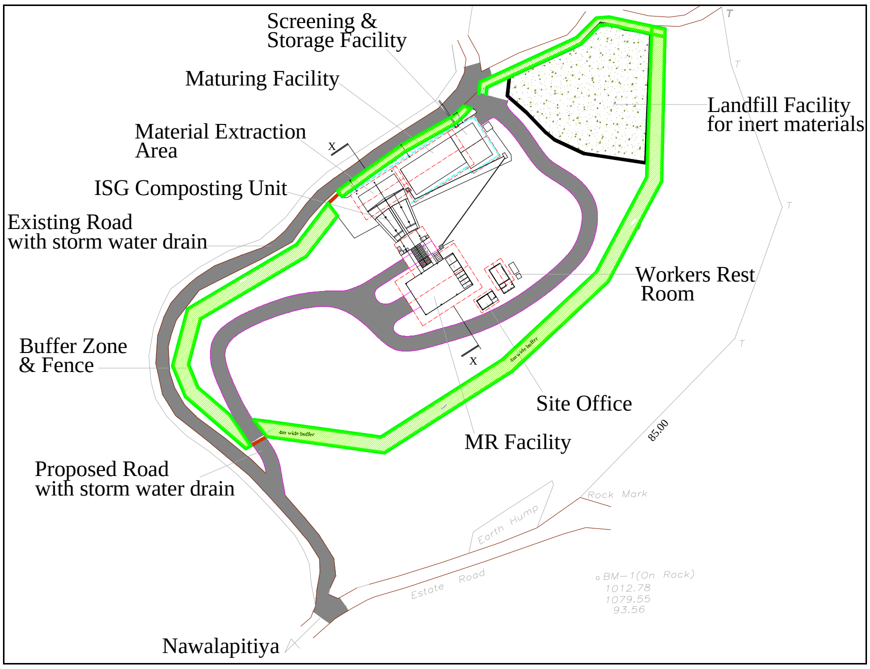

Figure 1: *The layout plan of the EPC*

2.3.1 Material recovery facility

The establishment of a MRF in a SWM system should be a feasible alternative to achieve sustainable development goals in urban areas if current household and curbside recycling can not prove successful in the long run [5]. The main function of the MRF is to maximize the quantity of recyclables processed, while producing materials that will generate the highest possible revenues in the market. The stages involved in designing a MRF system to process commingled recyclables were receiving of the materials in the hopper, the primary sorting of the materials in the conveyer, manual sorting of the individual materials and baling and separation of materials for transport. The functional space requirements for different categories of wastes, number of workers, ergonomics and storage space were taken into account in designing the MRF ($221m^2$).

As shown in Figure 2, incoming mix wastes to the MRF should be directly emptied from compacter trucks (tractor trailer) to unloading area where possible recyclables should be separated as much as possible to different categories such as polythene, papers, plastic, metal and glass, and others. After that, all the remaining materials should be pushed to the sloppy mesh area. Workers from both sides of the mesh will rake the materials where debagging process is happening, since it is easy to separate recyclables and rapid biodegradable. Manual raking method could be done at this area to debag and separate recyclables such as papers, polythene, glass, etc. Heavy particles which will roll down at high speeds through the sloppy mesh can be collected to a separate bin that is fixed to the edge of the mesh.

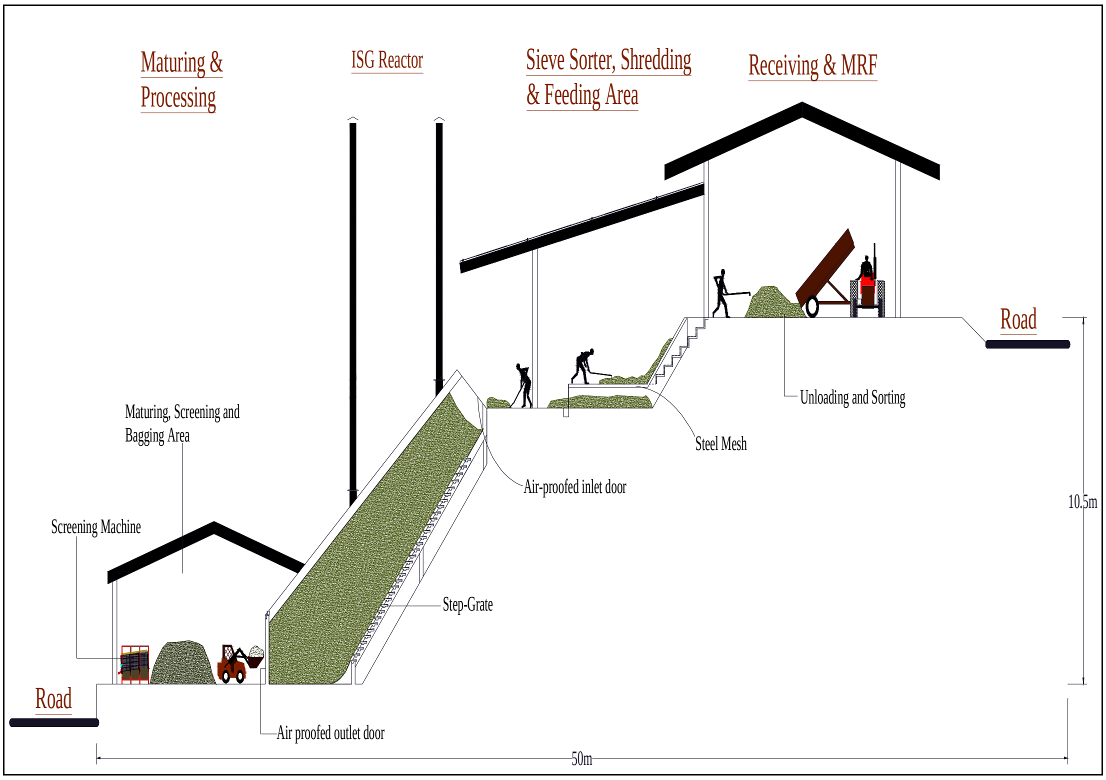

Figure 2: *Operational activities of MRF and ISG unit*

These particles are removed considering the types of wastes and collected in containers for eventual storage, size reduction of large biodegradable materials that will be composted along with small ones that was originally sieved. The recyclable materials like plastics, paper, etc. will be bailed using a press and transported to re-processing centers while the compost will be sold locally to tea estates. The remaining materials that cannot be composted and recycled will be disposed in a landfill meant only for inert materials.

2.3.2 The composting facility

Out of all available compositing systems, considering the terrain, the ISG composting system which was developed at the University of Peradeniya is the best and most suited to the type of wastes, climatic conditions and ease of operation. In fact, it is the least cost in terms of plant size and operational costs. This system consists of a manual or mechanical de-bagging unit, a concrete and stainless steel composting unit and a backend-sorting unit (manual or mechanical sorting and sieving). The compost unit has step-grates and vertical chimneys to facilitate aeration, where the top and chimney surfaces are blackened to create a draught at the bottom of the chimney, permitting air to enter the unit through the step [6]. The chimney effect is most advantageous than any other system.This system is unique since the operational costs are considerably low, and it has minimum moving parts. The system is virtually free from odour and any type of organic wastes could be treated.

Retention time of 28 days, bulk density variation over 28 days , repose angle of 45^o and 5 % slopes on sides and roof, dimensions; length, height, width, chimney design (the chimney height based on temperature variations between inside and outside to obtain an aeration rate of 0.36 to 0.39 m^3 of air per day per kg of volatile solids in a mixed urban waste), inlet and outlet openings, number of concrete steps, size and angle, total loads, foundations, columns, beams, side walls, roof structure, leachate pit and maturity shed for minimum of 30 days were the parameters and criteria used in the design of a 5.5 tonnes/day ISG plant. It is expected to have a minimum physical life of 25 years. However, regular maintenance is required of the steel fabrications, but the major part of the structure will be made from concrete, which will require yearly rehabilitation works for esthetic reasons. The Inclined step grate

Unit was located close to the entrance to get the maximum advantage of the existing slope. The inclined floor under the step grate was concreted to protect from erosion.

At the stage of removal from the back-end of the ISG, the wastes with or without recycled materials, have been stabilized but not matured to be termed “compost”. The removal can be done manually or else a small loader could be used. Employing a loader is a better alternative since it is safer as well as very efficient. After that, unloaded stabilized wastes will be made into piles for maturity over a period of 30-45 days. Much higher piles can be made with a loader and they could be as much as 3 meters. Moisture retention is higher with larger piles. If the need arise, moisture can be added to the piles and allow for maturing process. Finally, each pile will be sieved by motorized rotary 5 mm sieve for producing quality compost to meet market demand with the required quality assurance. Leachate collection drains were constructed from the ISG unit, MRF and sorting & feeding area to flow leachate and wastewater into one collecting tank. The collected leachate will be pumped and sprayed inside the ISG units, since the moisture requirement is higher than leachate formations. However, it is important to have adequate stocks of dried recyclable materials to absorb excess leachate formed during the rainy seasons. However, the wastewater from washings will be used as irrigation for buffer zone.

The type of compost produced from this process is unique since the waste materials undergo a degradation phase at high temperatures (70^o - 75^oC) for a period of 7 days. This type of compost is now termed "Thermophilic Compost". The recent research at the University of Peradeniya indicates that this compost is much better than inorganic fertilisers, producing much higher sustained crop yields since Thermophilic Compost lasts much longer in soil than conventional compost made at low temperatures.

2.3.3 Residual landfill

The objective of the designing of final disposal site is to prevent or reduce as far as possible negative effects to the environment from the waste arriving at EPC. Based on other facilities and treatment methods at the EPC, about 12.5 % of incoming waste would remain for eventual land filling.

Residual materials after composting process or materials that were sorted prior to composting operation will be placed in the landfill. Then, it will be compacted to a density of 800 kg/m^3. Hence the required landfill volume for ten years is 4927.4 m^3.

The land filling operation will be done every seven days or depending on accumulated ‘compacted’ volume to dispose it in a cell which will be covered with a 6 " soil layer. Temporary drains will be installed in order to divert storm water accumulated in the cell, to existing drainage system in rainy seasons as shown in Figure 3. Base liners and leachate collection system are not essential to be constructed in the landfill facility, since it is an inert landfill. However surface and subsurface drains will be established to divert runoff water.

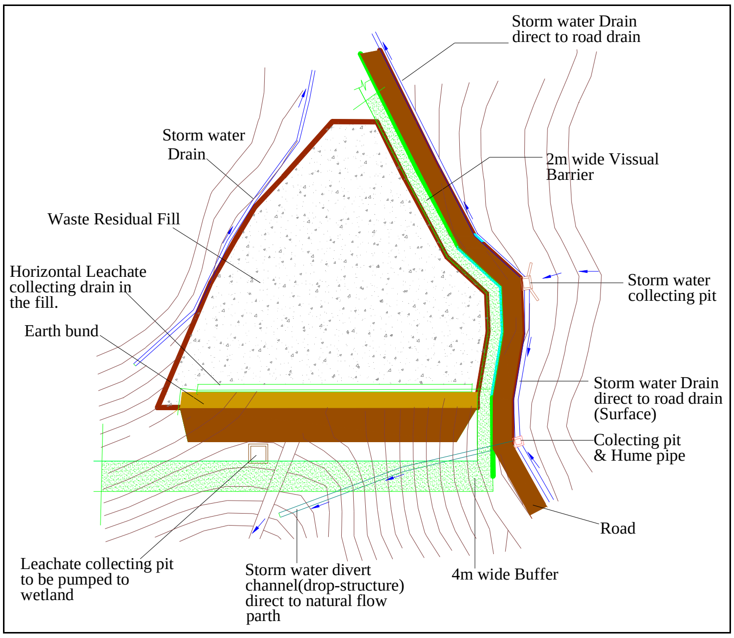

Figure 03: *Layout plan of the Inert Landfill Facility*

3. Discussion

The selection of a suitable site was a priority for the LA and it is more than likely for public acceptance of the new site. The most important feature of the project was to move away from the River and locate EPC in an abandoned tea estate. The buffer zone of trees, shrubs and fence reduce the effects of pollution from the EPC. It will have negligible level of pollution from the technologies that will be applied and daily operations carried out in the EPC. However, it is best to provide a leachate management facility, since the rainfall is high and constructed wetland is ideal to treat dilute concentrations of leachate [7]. Also, it is important to have an effective and efficient incinerator for hospital waste disposal at the hospital premises itself, thus healthcare wastes at the landfill site can be avoided.

It is likely that considering the enthusiasm of the UC officials, the EPC will be an attractive site for visitors or even an outing for the locals as an educational and relaxing site. An additional landmass given for landscaping and for the cultivation project that the UC is envisaging might become an eye opener for reclaiming such lands. In fact, funds could be made available if these lands could be given for the project so that compost could be used for rejuvenating the lands to replant tea or convert back to rain forest.

This will not only be a contribution to combat climate change and reduce the influence on global warming, but also provide immediate environmental benefits offsetting escalating environmental costs of poor health of the population. In one of the studies,[8] a value of Rs 60 per capita was derived for costs incurred due to poor solid waste management. The evaluation was done for Colombo and it could be more than applicable to Nawelapitiya. Therefore, health sector and the population will save more than Rs 800,000 annually. The health authorities spend as much as Rs 4.4 billion as recurrent expenditure on public health services. It can be expressed in terms of per capita and it amounts to Rs 231. Also it may be possible to approximate 10 to 50 % of this value on account of poor solid waste management. Thus, based on a percentage 20 %, a value of Rs 46.2 per capita may be the recurrent expenditure on vector control caused by solid wastes. It will amount to Rs 660,000 for Nawelapitiya.

In considering direct benefits, a point source separation programme should be introduced such that the quality of recyclables will be more, thus fetching higher prices which will augment revenue. In fact, the cost of collection will also reduce, saving on fuel and other resources. Inevitably, the environmental benefits will be much more. Hence, awareness programmes, should be conducted to change attitudes of the communities and leadership qualities of individuals enhanced so that grass root level point source separation programmes will be successful.

The awareness programmes should then be coupled with efficient collection system to prevent fly infestations. Enclosed bins are required to stop the breeding grounds, thus eliminating the problem at source. The emission of leachate is very less in the high temperature composting system of ISG. In the event of poor operations, there will be small quantities that will be recycled. In addition long term fibrous biodegradable materials will be mixed with the raw wastes to reduce leachate generations. The wastewater stemming from washing of the MRF will be used for irrigating the buffer zone of the environmental protection centre. It will be aesthetically landscaped to reduce if there will be any odour emissions and to protect the surrounding natural environment. It is also possible to incorporate biofilters to the chimneys [9] if overloading of the reactors will take place causing high polluting gas emissions. The made compost can be improved depending on the market demand for different crop management practices. Thus, inputs such as nitrogen, phosphorous and potassium can be mixed in the form of inorganic or organic into compost piles after the maturity phase is completed or just before bagging the compost. The materials that cannot be composted and there is no other market for non-biodegradable materials will be transported and disposed in the inert landfill. At present, it is the major drawback for efficient management of the facility, since the construction of the landfill is yet to be completed.

The revenue from these processed materials will not be sufficient to meet all of the expenditure if the venture capital will have to be repaid with an interest that is prevailing today. Therefore, the UC will be compelled to impose a ‘green tax’ and the level of taxation can be reduced if the UC is able to secure subsidy or grant to meet some of the capital requirements. The UC also has the option of providing the cost of wages to negate the ‘green tax’. However, it will be very risky as a solution, since there will not be the possibility to buffer losses in the event of market failures, particularly so of selling plastic based materials. The best alternative is to find partners for investing as forward contracts for compost and other recyclable materials. This will reduce the risk. Thus, benefits of banking at high interest rates will be transferred to enterprises. Further remunerations could be attained if collective production systems are developed within the same region to claim for carbon credits. It is technically and financially feasible sustainable integrated solid waste management system for protecting the environment and future generations.

4. Conclusion

The EPC will prevent the present pollution loads caused by dumping of wastes. In contrast, the application of mitigation technologies will minimize and enhance the present environment. However, the environmental parameters should be monitored and reported. In the period of construction, adequate protection will be provided to minimize soil erosion. The compost plant is made operational, however hampered with the lacking of landfill facility that requires completion in the near future. Another important addition is a wastewater treatment facility and it is recommended to establish a constructed wetland. The facility will function efficiently, since the Central Government provided the funds to establish the facility and now awaiting for the remaining capital to be injected to the project. The capital is vital, since the facility cannot function viably based on the income from sale of reusable and recyclable materials. Indeed, the facility will no doubt support the development of the city for future generations as a sustainable system.

5. Acknowledgement

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