Presentation of the PROJECT

Introduction of Quezon City Site: Payatas Controlled Disposal Facility

The Quezon City Site, Payatas Controlled Disposal Facility (PCDF) is infamously known for its tragic trash slide last 10th of July 2000, which killed approximately 200 residents that resided near the open dumpsite (Pagano, 2000). The site was reopened and was taken over by Quezon City in 2001 to convert into a controlled dump per the approval of Republic Act 9003, Ecological Solid Waste Management of 2000. The controlled dumpsite was closed in 2010 and the sanitary landfill was opened at the same year. Eventually, the sanitary landfill was closed in 2018 (see Annex 1).

PCDF, at present, houses both closed controlled dump and sanitary landfill. The sanitary landfill comprises approximately 7 hectares while the controlled dumpsite is approximately 23 hectares according to Engr. Luis Sabater, the Quezon City representative for PCDF (see Annex 2). The site is divided into different areas to determine which part is the sanitary landfill and which part are the controlled dumpsites (see Fig 1). The site that will also be developed includes a 4-hectare land adjacent to the main disposal site, which is occupied currently by informal settlers (see Fig 2).

In line with these, the following sections of the paper will be describing our proposed plan of action and design concept of developing PCDF into a green and sustainable site. A look into the future of what Payatas can be, with proposed plans and methods to achieve this green and thriving community.

Improvement of the Site Area

With the closure of the controlled dumpsite in 2010 and the closure of sanitary landfill in 2018, PCDF started its post-closure care management for the controlled dump in 2011 and started their post-closure care management for sanitary landfill in 2018, in accordance with RA 9003. Though care management has started and is still ongoing, PCDF are still in unfavorable conditions to put out redevelopment plans.

The site form mentioned several approaches and management techniques the researchers may include in their respective plans. This made us include plans of improvement of the site before the main development plans and design. The following plans are divided into three (3) sub-categories to expound the plans for the site area, namely; for air, water, and soil improvement. The team also discloses the fact that, though it is vital to know the present conditions of the site in order to generate a more fruitful, detailed and sound suggestions for the improvement of site, the constraints of the present pandemic and protocols of Inter-Agency Task Force on Emerging Infectious Diseases (IATF) in the Philippines inhibited us to do so. And thus, the team will be putting forth a generalized set of plans for the following sub-categories.

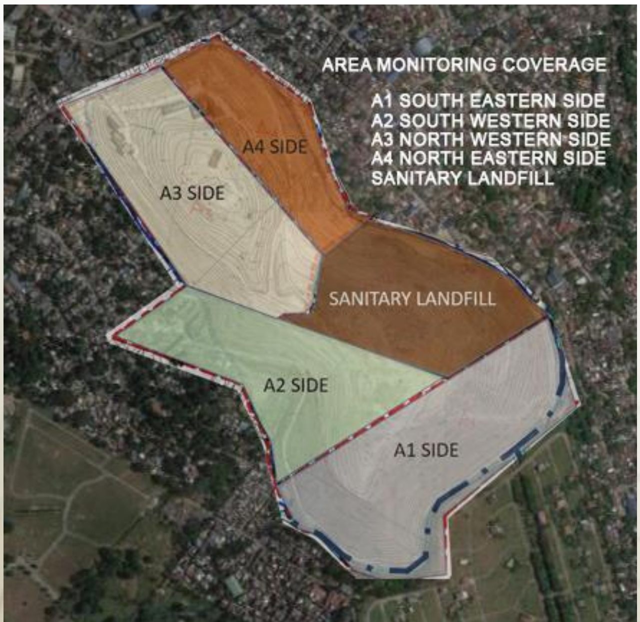

Fig 1. Payatas Area Monitoring Coverage

Fig 2. Payatas adjacent 4-hectare area

Air Improvement

One of the main problems from landfill and dumpsite is its harmful air emissions, commonly known as landfill gas or LFG. LFG is roughly composed of methane, carbon dioxide and small amounts of other organic gas.

In 2004, a 100-kilowatt methane power plant was launched in PCDF to convert methane into electricity, in partnership with Philippine National Oil Corporation (PNOC). In 2007, Quezon City successfully drafted a Biogas Emission Reduction Project, a project plan to reduce the LFG emissions of the controlled dumpsite, a public-private partnership with Pangea Green Energy Philippines, Inc. Capture, storage, refining, and flaring of landfill gas (LFG), as well as the conversion of methane into electricity, were all part of the project plan. The project has been registered with the UN Framework Convention on Climate Change (UNFCCC) as a Clean Development Mechanism (CDM-PDD, 2007).

Waste-to-Energy Plant, The Drawback

Although this project in Payatas was the Philippines' first waste-to-energy project and has since become a globally recognized waste-to-energy model, there are some drawbacks that can be further improved. According to Chua (2020), in his critical review of Payatas Waste-to-Energy project, the author used *methane emissions reduction indicator* to assess the project. The plant reduces methane emissions by 116,339 CO2e metric tonnes per year on average. In Metro Manila, the region that Quezon City is in, where Brgy. Payatas is located, municipal solid waste (MSW) emits 173 gigagrams of methane per year, which is equivalent to 4,325,000 metric tonnes of CO2e. A calculation of methane emissions reduction index was made, where 0 denotes an unsuccessful project and 1 denotes a completely efficient project.

$$\frac{methane\ emissions\ saved\ from\ project}{methane\ emissions\ from\ Manila\ MSW}$$

$$\frac{116339}{4325000} = 0.02689919075 \approx 0.027$$

This plant's emissions reduction index of 0.027 can seem low and inefficient at first glance, but when one considers that it saves 2.7% of Metro Manila's MSW methane emissions, its contributions to methane reduction efforts can be considered significant (Chua, 2020). Due to plant operation limitations caused by a low generator capacity of 200 kW, only 20% of the methane extracted from the dumpsite is currently used to power the electricity generator, indicating the lost-potential for improved production. Since the remaining 80% is simply converted to carbon dioxide, not only is the methane resource wasted, but it also increases the amount of carbon dioxide pollution in the region (Tumamao-Guittap et. al., 2017). However, even if this potential is not fully realized, the plant is already reducing total methane emissions, so any untapped potential would only support future operations, which shows that the project's environmental component is fairly decent (Chua, 2020).

Though the project is fairly decent, one cannot deny the fact that 80% is still converted into CO2. Several papers indicate that methane to CO2 conversion is fairly better because CO2 is a lesser harmful greenhouse gas than methane, but it is nonetheless still a greenhouse gas.

The Proposed Greenhouse Gases Reduction Plan

As what is found lacking in the Pangea plant from the critical review of Chua (2020), there is an abundant excess of methane that is not converted into electricity. This excess methane is flared to become carbon dioxide. The group suggests that the plant should upgrade the generator's capacity to utilize all methane-to-energy conversion and maximize their methane-to-electricity conversion. So that they can expand the distribution of their grid electricity and many will benefit. Upgrading and maximizing the plant's methane-to-electricity conversion means that there is no need for flaring. If ever there is still some excess methane that inevitably needs to be flared, it will only make less carbon dioxide compared to the initial 80%. Lesser carbon dioxide indicates a lesser greenhouse gas contribution of Payatas.

For the remaining carbon dioxide that needs to be handled, the proposed reduction plan of the group is carbon sequestration by carbon farming and phytoremediation. As all good functioning habitats take up and store a large amount of carbon in soils, sediments, and plants, the natural environment will play a critical role in addressing the climate crisis (Gregg et al., 2021). Improved land stewardship is the most mature and cost-effective carbon dioxide reduction strategy currently available (Griscom et al., 2017).

The method of extracting carbon dioxide from the atmosphere with the aim of mitigating global climate change is known as carbon sequestration. Carbon sequestration occurs as carbon dioxide is absorbed by the soil, as well as the plant's root, stem, and leaves. It includes putting in place measures and procedures that have been shown to increase the rate at which carbon dioxide is removed from the environment and converted to soil organic matter and/or plant matter. Phytoremediation is a technique for removing toxic substances from the air, soil, and water using living plants. It is a more cost-effective option as compared to other remediation options. It does not necessitate a large cost in equipment (Wang et al., 2002; Chua et al., 2019), and maintenance is sufficient.

Though all trees, especially the ones with thick woody bark, can sequestrate carbon, the group suggests bamboo such as Giant bamboo (*Dendrocalamus asper*), Bayog (*Bambusa merilliana*), Kawayan Tinik (*Bambusa blumeana*), Buho (*Schizostachyum lumampao*), Kawayan kiling (*Bambusa vulgaris*), Anos (*Schizostachyum lima*) and Kans grass (*Saccharum spontaneum*). Bamboo plant species are the main phytoremediator plant as this grass is found to have a great potential as a phytoremediator. Woody bamboos have a sequestration and carbon storage rate of 6 - 13 Mg ha-1 yr-1 and 30 - 121 Mg ha-1, respectively. Bamboo grows fast, taking between 120 to 150 days to a growth cycle completion. It has a high carbon sequestration potential due to its effective CO2 fixation and rapid biomass accumulation (Nath et al., 2015).

Emission Reduction from Construction of the Design Plan

Since Payatas is situated in Metro Manila, the metropolitan area of Luzon, Philippines, the group suggests that the materials and equipment shall be sourced within this metropolitan area to reduce the carbon emission from construction phase of the design plan. Construction workers can also be sourced from Payatas residents themselves. Not only will this reduce carbon emission from daily transportation if workers are sourced elsewhere, this will also be a contribution to the employment priority that is mentioned in the City Site Form.

Water Management

The second main problem from dumpsite is its effect on nearby water systems, e.g. groundwater and surface waters. As rain water percolates through the mounds of trash and soil, it can reach aquifers and nearby surface water. This percolated water is what is called leachate (Jayawardhana et. al., 2016). This reason is why controlled dumps and sanitary landfills came into existence, to prevent and to manage leachate generation through groundwater and surface waters.

As PCDF was converted from open dump to controlled dump in 2001, and a portion was converted to sanitary landfill in 2010, changes have been made to manage its leachate generation. However, since only a portion was a sanitary landfill, and the rest was a controlled dump, leachate prevention is not in its maximum potential.

In accordance to the Implementing Rules and Regulations (IRR) of RA 9003, there is a set of meticulous minimum requirements and considerations for operating and designing sanitary landfills to manage leachate system, such as base liner system using clay and/or geosynthetic membrane, a system for collecting and removing leachate must be provided and planned, containment systems must be built into leachate storage facilities to prevent leachate from spilling and migrating into groundwater or surface water, the discharge of treated leachate effluent should be monitored for pH, 5-day Biochemical Oxygen Demand (BOD5) and Total Suspended Solids (TSS), and so on. However, for minimum requirements and considerations for operating a controlled dump to manage leachate system, soil cover, monitoring of groundwater and surface water are mentioned, but leachate system and treatment are not required.

According to Engr. Sabater, when asked with regards to the leachate system of PCDF, leachate recirculation method and phytoremediation is being utilized for the controlled dumpsite, while Advanced Oxidation Process (AOP) is being used by the developer for sanitary landfill which is still under test-run stage (see Annex 3). Monitoring of surface water and groundwater is being undertaken quarterly every year, as required in IRR of RA 9003.

A Plunge in the Existing Leachate System

Landfill recirculation is the method of returning leachate to the landfill from which it was abstracted. This method of reapplying leachate to waste masses repeatedly saves money on off-site disposal and increases landfill gas output (Karidis, 2018). AOP, on the other hand, is a technique for removing organic pollutants from wastewater that primarily uses hydroxyl radicals (·OH), the ultimate oxidant (Ghime & Ghosh, 2020). AOPs work by using highly reactive hydroxyl radicals that can oxidize almost any compound in the water matrix. As a result, once formed, ·OH reacts in an unselective manner, fragmenting contaminants and converting them to small inorganic molecules quickly and efficiently (Munter, 2001). AOP is emerging to landfill management, which makes the inclusion of this in PCDF beneficial, but only to the portion of sanitary landfill.

Though landfill recirculation is highly applicable to the site due to the existence of LFG-to-electricity plant, landfill recirculation method may need to be replaced since the site will be redeveloped and be opened to the public.

The Proposed Water Management System

To prevent further generation of leachate, the team proposes a plan of soil capping and storm water run-off redirection. Since the majority of the site was an open dump before turning into a controlled dump and that only a portion is a sanitary landfill, base clay liner for the protection of groundwater may be non-existent. And so, application of soil capping with clay liner or geosynthetic membrane and redirection of the storm water run-off are proposed (see Fig 3 & 4). Redirection can be done through the use of swales, in which the team included in the design plan. The retention pond on the main site will be used for the storm water collection which the site can use for irrigation of plants and trees to the proposed eco-park. And, overflowing water can be redirected to the retention pond in the 4-ha area, which will be served as wastewater treatment for the proposed agro-industrial facilities in a later phase of the plan (see the Implementation Plan). Similar process was also done to Hiriya Dumpsite in Tel Aviv, Israel, which is now called Hiriya Park (Mordas-Schenkein, 2015).

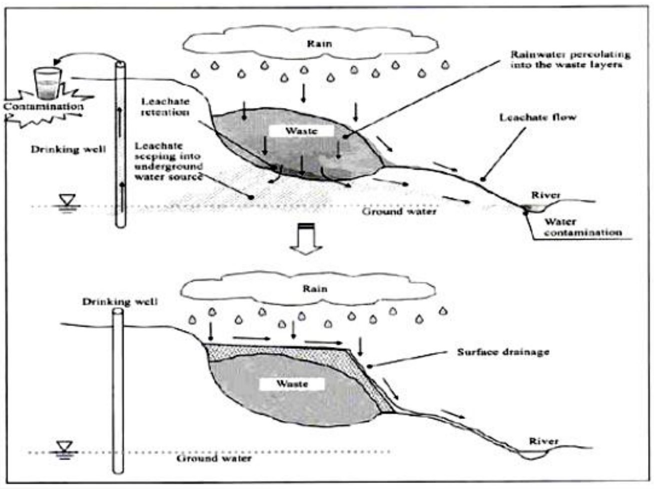

Fig 3. Purpose of soil capping (NSWMC, 2010)

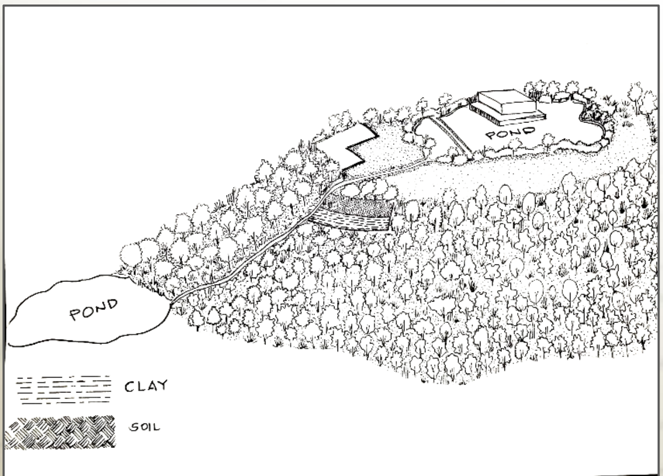

Fig 4. Proposed storm water run-off redirection

Before proposing a water management plan, the team assessed the current status of the surface water and groundwater in the site. With the provided status report of groundwater and surface water by the City (see Annex 4 & 5), the team assessed this using Water Quality Index (WQI). The weighted arithmetic index method by Brown et. al. (1972) was used for the calculation of WQI.

$$WQI = \sum WnQn$$
$$WnQn = Wi \times Qn$$
$$where\ Wi = \frac{K}{Sn}\ and\ Qn = \frac{Vn}{Sn} \times 100$$
$$where\ K = \frac{1}{\sum \frac{1}{Sn}}$$
$$Sn = standard\ value$$
$$Vn = \ Annual\ Average\ of\ Parameters$$

The reports were taken from different groundwater and surface water sites (see Annex 6) provided by the City. The standard values were taken from DENR (DENR, 2016). With the water quality classification based on WQI values (see Table 1), the results appear that the groundwater is poor to good water quality while the results for the surface water are all in >100 WQI which means unfit for consumption (see Table 2). These results indicate that improved management is needed.

Table 1
Classification of Water based on WQI Values

Water Quality Index Level	Water Quality Status
0-25	Excellent water quality
25-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unfit for consumption

Source. Brown et.al., 1972

Table 2
Results of Groundwater and Surface Water WQI

Location	WQI Result	Quality Status
GW1	29.7	Good
GW2	56.5	Poor
GW3	28.4	Good
SW1	167.9	Unfit
SW2	152.9	Unfit
SW3	131.3	Unfit
SW4	243.2	Unfit
SW5	172.2	Unfit
SW6	97.0	Very Poor

Note. GW stands for groundwater, SW stands for surface water

Due to the constraints of not being able to fully assess the current status of generated leachate, the team will be delving to different sets of proposed water management methods that can be applied in different circumstances of a dump and landfill site. Weak leachate can be treated in aerated lagoons. Before being discharged to a watercourse, the leachate is often passed through a specially planted reed bed. Leachate with high concentrations of ammonia can be removed by “stripping”. The pH of the leachate is raised to 10.5+ before being flashed off to the atmosphere under vacuum. Almost always, the leachate must be heated first. This disposal method has a high overhead cost, but a low capital investment. For leachate with high levels of BOD, COD and ammonia, the most cost-effective form of treatment is intense biological oxidation. The sequential batch reactor (SBR) is the most widely used technology (Robinson, 2005).

SBR is a biochemical procedure used to kill a variety of toxins. SBR differs from activated-sludge methods in that it combines all treatment units and processes into a single basin or reservoir, whereas conventional solutions focus on several tanks. SBR is commonly divided into five stages: fill, respond, settle, draw, and idle (Aziz, 2011). SBR treatment has been shown to be useful in removing NH3–N and COD from leachate. About 95 percent of the recalcitrant compounds may be extracted with an initial COD concentration varying from 3500–26 000 mg L^{-1}. Similarly, almost complete removal of NH3–N at concentrations ranging from 100–1000 mg L^{-1} was possible (Kurniawan, 2010). SBR has a range of benefits for leachate treatment, including ease of operation and repair, the ability to handle a wide variety of contaminant loading in a single reactor, less sludge bulking, shock loading resistance, and no special clarifiers available, which reduces operating costs.

With the above suggested methods, there also exists bioremediation methods that not only can be cost-effective, but are environmentally-friendly. The emerging bioremediation methods for leachate and wastewater are phycoremediation and mycoremediation. Phycoremediation is the use of algae for remediation process. Because of its effective separation of nutrients, organic and inorganic compounds from wastewater, the phycoremediation method has received considerable popularity as a natural bioremediation strategy for high strength wastewater treatment. Carbon, nitrogen, phosphorus, and trace elements in wastewater are assimilated by microalgae during the phycoremediation process for digestion and cell formation, resulting in superior quality effluent (Subramaniyam, 2016). However, owing to toxicity caused by high concentrations of organic and inorganic compounds, the phycoremediation process has not been effective in handling condensed landfill leachate on its own (Nguyen et.al, 2017). As a result, landfill leachates need to be diluted 10–20 times in order to minimize their inhibitory effects (Paskuliakova, 2018). However, using phycoremediation can produce a biomass that can be converted into energy (Nair, 2019). The study's findings suggest that using phycoremediation for tertiary treatment of landfill leachate may be a sustainable alternative because residual nutrients were absorbed by microalgae for beneficial biomass processing and given superior quality effluent with reduced environmental hazards.

Mycoremediation is an innovative fungal-based process where fungi are used to break down compounds that are resistant to bacterial degradation because of their oxidative abilities (Siracusa et al., 2020). Fungi are an ideal candidate for the remediation of various contaminants due to their robust growth, extensive hyphal network, development of flexible extracellular ligninolytic enzymes, resistance to heavy metals, high surface area to volume ratio, presence of metal-binding proteins, and adaptability to fluctuating pH and temperature (Akhtar & Mannan, 2020). Compounds that are of toxic nature are broken down by the correct mixture of fungi population. The fungal mycelia themselves vanish after the remediation process is completed because there are no more pollutants for them to consume (Duta & Hyder, 2017).

According to Siracusa et al. (2020), Ascomycetes, a phylum of kingdom Fungi, have the ability to turn environmental contaminants by growing in neutral pH, resisting harmful conditions, and chelating metal ions, resulting in not only decontamination but also detoxification of the treated matrices. *Saccharomyces cerevisiae* has been the only Ascomycetes used in the treatment of landfill leachates so far. The *Lambertella sp.* strain was found to be essential for depletion of the recalcitrant portion of old and intermediate leachates. *Lambertella sp.* was found to be very efficient at activating the transformation of recalcitrant compounds in old landfill leachate and/or directly metabolizing them. The myco-based method involving *Saccharomyces cerevisiae* was found to be very promising in terms of *Lambertella sp.* ability to minimize the clastogenic effects of the treated landfill leachates' organic fraction, implying that Lambertella sp., for the treatment of mature leachates, could be a very promising candidate.

Soil Improvement

The third problem to be addressed in PCDF site improvement is its soil. With the proposed redevelopment of PCDF into a green and sustainable site, the improvement of its land is imperative and should be done firstly, in order to make the redevelopment happen in the first place.

Improving Soil Bearing Capacity

It is expected that the team wouldn't be able to determine the site's soil structure due to inability of on-site visit. And even if on-site visit is possible, the overall structure of the site wouldn't be easy to determine in view of the fact that the site is in layers of soil and trash. Due to this, with also the guidance of the Quezon City site form, the researchers took an educated assumption that the site possesses unstable form. And so, our design plan that we will discuss later, will only include infrastructures that would only require light materials without the need of foundation.

But to further improve the site's ability to hold the infrastructures that will be included, methods for improvement of soil bearing capacity are incorporated. The suggested methods to improve the bearing capacity of soil are compaction, confinement, and replacement of poor soil (Anis, 2015). Compaction of soil will increase its density and shear strength which will increase the bearing capacity of soil. The IRR of RA 9003 also requires the compaction of the dumpsite, and so this is already given. For the confinement of soil, there is a reduction in settlement, resulting in an increase in the soil's bearing ability (Singh et. al, 2007). One of the things that can be used for confinement is gabion walls, which the team has chosen for aesthetics and soil slope stability that will be thoroughly discussed later. For the replacement of poor soil, though this method can be uneconomical, replacement can be done as a last resort method and can be used only for parts where the infrastructures will be put to make it more cost-effective.

Slope Stability - Gabion Walls

Payatas is infamously known for its tragic trash slide accident in 2000, and so slope stability plan and design is essential. In compliance with IRR of RA 9003, PCDF currently has sheet piles for slope protection and improvement (see Annex 7). In order to improve the existing slope protection, and in addition to our PCDF development design which will be discussed later, the team will be adding retaining walls, using gabions.

Fig 5. Gabion Walls (Maccaferri PH, 2016)

Gabions (see Fig 5) are enclosures, welded wire cage or box that can be filled with anything from rock to brick to concrete debris. Gabion walls are a partly flexible block structure used in construction and landscaping for slope stabilization and erosion control (Hamakareem, 2018). The following are the advantages of using gabion walls for slope stabilization.

Advantages (Hall, 2021; Hamakareem, 2018)

- **Environmental friendliness.** Due to the flexibility for material source of filler for gabion walls, onsite materials can be used for the fillers. The gabion cage can be filled up with recycled materials. The vegetation growth is also supported over time because of the gaps in the soil between the filling materials.
- **Cost-effective.** Transportation costs and related fuel consumption are reduced when onsite material is used as filler. Gabions are also very cost-effective for a retaining wall because they require little excavation or land planning.
- **Flexibility**. This function allows the gabion to settle and deform without breaking down or losing its effectiveness. Specifically, when encountering unstable terrain and flowing water.
- **Permeability.** It allows for automatic and simple drainage, negating the need for drainage pipes to be installed.
- **Durability.** Gabion walls can have a very high resistance to atmospheric corrosion if well bonded zinc coating on the wire for the cages will be utilized. The stone fill conforms to the contours of the ground underneath it and has sufficient frictional strength to eliminate the need for a base. As silt and vegetation fill the voids and reinforce the structure, the wall's strength and effectiveness can improve over time.

- **Sustainability**. Gabion walls are used as shade screens in hot climates to provide passive cooling by allowing air to pass through, allowing for ventilation.
- **Aesthetics.** Gabions can be made to look natural and blend in with the surrounding environment by using filler materials excavated from the site or the surrounding terrain

Disadvantages

Some articles claim that gabion walls, specifically the cages, can be subjected to wear and tear. However, properly galvanized or coated cages have been put out in the market for this type of problem. Another claimed disadvantage of gabion walls is its subjective unappealing-aesthetic to the eyes. But, this issue can be solved with proper designing.

Slope Protection and Erosion Control

Not only will the gabion walls be used, the team, with guidance of L.Arch Bari C. Panopio, also set out plants for slope protection and erosion control (see Table 3). These plant species are of native and non-native species that will also be complementary to the gabion walls.

Table 3

Slope Protection and Erosion Control Plants Species

Type	Species and Common Name
Trees	*Crateva religiosa* (Balai Lamok) *Intsia bijuga* (Ipil) *Lagerstroemia speciosa* (Banaba) *Millettia pinnata* (Bani) *Pterocarpus indicus* (Narra) *Trema Orientalis* (Anabiong) *Vitex parviflora* (Molave) *Wallaceondendron celbicum (*Banuyo)
Shrubs	*Cymbopogon citratus** (Lemon grass) *Saccharum spontaneum** (Talahib) *Vetiveria zizanioides** (Vetiver grass)
Ground Covers	*Arachis pintoi* (*Yellow Peanut Plant) *Zoysia matrella* (Manila grass)

Note. *Non-native plants (Pelser et.al, 2011; Fernando et.al, 2018)

Soil Quality Improvement - Phytoremediation

There are several methods to improve the quality of soil but the most widely-known, cost-effective and not to mention, green method is phytoremediation. Phytoremediation is a form of bioremediation in which plants are used to eliminate, convert, stabilize, and/or eliminate pollutants from the soil and groundwater. Several plants and trees can be used for phytoremediation, but the researchers, with the guidance of Dr. Edwin R. Tadiosa, chose specific native and non-native species that not only are for phytoremediation, but also for aesthetic purposes of the proposed eco-park (see Table 4). Though there are non-native species included, the researchers suggest increasing the frequency of the native species as this will be better for the overall ecosystem.

Table 4

Phytoremediation Plants Species

Type	Species and Common Name
Trees	*Terminalia catappa* (Talisay) *Casuarina equisitifolia* (Agoho) *Calophyllum inophyllum* (Bitaog)
Shrubs	*Aglaia odorata* (Sinamomong-sungsong) *Hedychium coronarium* (Philippine Kamia) *Melastoma candidum* (Melastoma) *Schefflera arboricola* (Umbrella plant) *Bougainvillea spp.** (Bougainvillea) *Codiaeum variegatum** (San Francisco) *Hibiscus syriacus** (Rose of Sharon) *Hibiscus rosa sinensis** (Chinese hibiscus) *Ixora chinensis** (Chinese ixora) *Kalanchoe blossfeldiana** (Kalanchoe) *Lantana camara** (Common Lantana) *Tagetes patula** (French marigold)
Grass	*Dendrocalamus asper* (Giant Bamboo) *Bambusa merilliana* (Bayog) *Bambusa blumeana* (Kawayan Tinik) *Schizostachyum lumampao* (Buho) *Bambusa vulgaris* (Kawayan killing) *Schizostachyum lima* (Anos)

Note. *Non-native plants (Pelser et.al, 2011; Fernando et.al, 2018)

Table 5

Biodiversity Plants Species

Type	Species and Common Name
Trees	*Diospyros blancoi* (Kamagong) *Dillenia philippinensis* (Katmon) *Barringtonia asiatica* (Botong) *Vitex parviflora* (Molave) *Ficus nota* (Tibig) *Ficus minahassae* (Hagimit) *Premna odorata* (Alagaw) *Alstonia scholaris* (Dita) *Dysoxylum gaudichaudianum* (Igyo) *Artocarpus blancoi* (Antipolo) *Bischofia javanica* (Tuai) *Clerodendrum quadriloculare* (Bagawak-morado) *Lagerstroemia speciosa* (Banaba) *Antidesma bunius* (Bignay) *Toona calantas* (Kalantas) *Agathis philippinensis* (Almaciga) *Ficus variegate* (Tangisang bayawak) *Afzelia rhomboidea* (Tindalo)

Note. All are native plants

Green and Thriving Neighborhood, Plans for the Area

After discussing the improvement of the site area, the plans and design of the area will be as follows. In order to create a green space and climate resilient area, nature-based solutions are applied. The team designed plans to incorporate these objectives while keeping in mind the best interests and needs of the project site. And thus, the team designed a series of plans that will cater these expectations and needs.

The Green Space, Biodiversity Plan

Payatas, being adjacent to the lungs of Quezon City, the La Mesa Watershed and Eco-Park, is being visited by migratory birds every now and then. With the City's expectation to bring forth a green space to the then-mount of trash in the infamous Brgy. Payatas, incorporating a biodiversity plan in the team's redevelopment plan will be the cherry on top. The biodiversity plan will consist of the aforementioned native and non-native plants and trees in the soil improvement. Not only will those help for the soil's quality, stability, and the site's aesthetics, the species will also cater to the diversity purpose of the area.

To cater for the emerging migratory birds in Payatas area, and the Payatas being closely adjacent to the La Mesa Watershed and Eco-Park, the biodiversity plan will also include native species that can be seen in the nature reserve (see Table 5).

Fig 6. Malabulak (Ramos, 2019)

Fig 7. Malabulak pattern in the design

This strategy will be able to cater not only the migratory birds, but also the native fauna of the country, because the species mentioned are all native and indigenous.

The Thriving Community, Design Plan

With the team's aim to cater the needs and expectations of the City, the team designed the Payatas Eco-Park, a community and ecological park that will comprise all the highlighted community needs and hopes to have. The team chose a design concept that will feature the history of Payatas, while accentuating its heritage and pride. With this in mind, the design concept that was chosen is *Malabulak*.

Malabulak (*Bombax ceiba*), a native seasonal tree in the Philippines, blooms in between February and March, showing its beautiful hues of orange and red highlighted by the absence of its leaves (see Fig 6). Used as both symbolism and physical concept for the site, Malabulak shows its vibrance when in season just like how the researchers aim to reach for the site. The shape of the flower can be used in the design, patterns in materials and planting arrangements (see Fig 7).

As part of the solution, the design required the use of gabion walls and forestscaping for soil stability, as the slope of the contours is 9.4% which is plantable. Swales are also present and are used to control the water flow directed to places where it can be treated properly.

Fig 8. Aerial view of the design

Fig 9. Animal Rehabilitation, Veterinary Clinic & Barn

Fig 10. Greenhouse, Aquaponics and Bee Haven

Fig 11. Eco-Museum (upper left), Lounge and Viewing Decks (bottom right)

Fig 12. Commemorative Wall

Animal rehabilitation and barns are also present, as there already exists a dog pound in that area (see Fig 9) The livelihood integrated in the design are bee haven, community gardens, one in the form of aquaponics, and maintenance of the facilities (see Fig 10).

For the design features, educational facilities are included since it is one of the needs of the community. Inside the eco-park design, there are provided open spaces used as multi-functional recreational areas. Lounging areas with gazebos, viewing decks for sightseeing, pavilion for small events, and the ecomuseum as an educational facility for all ages (see Fig 11). In the design, a commemorative wall, made of gabion walls, is put to help remember the accident on July 10th, 2000, and honor the many lives and livelihoods that were lost (see Fig 12).

The design aims to function as a reminder that change does not necessarily mean sweeping out the existing elements to create a new one, the design philosophy is inspired from Buckminster Fuller, "*You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete*."

Community Benefits

With the following plans the team have put out, the researchers gauged the benefits the residents of Payatas and nearby barangays will garner, with the Payatas residents its main beneficiaries in mind. The following are the benefits the community may have.

Environmental Benefit

Assessing and including the environmental aspect of the site to the redevelopment plan will further improve the overall environment of Payatas. The team has done its best to assess the supplemental improvement PCDF needs in order to further cater the needs of Payatas residents. Inclusion of the improvement of PCDF's air, soil and water management will expedite the site's closure care management.

In addition to this, the incorporation of area's management in the team's redevelopment plan aims to bring back its once title as the Land of Promise (Lupang Pangako). The once site of tragic and devastating incident, aims to be the Land of Promise it rightfully longs to be.

Health Benefit

With the inclusion of site's management in this redevelopment plan, the paper will also be able to tap its health benefits to the community of Payatas. In 2017, there have been circulations of a series of news about the outcries of Payatas residents with regards to the site's odor and potential harm to their health (Cruz, 2017). With PCDF being close to the residential area, the proposed redevelopment plans aim to ease and completely get rid of potential harm to the resident's health. The plan of improving the site's overall management is the best way to combat the potential harm.

Community-based approach benefit

In accordance with the proposed design plan of this paper, the team also took into consideration what the main beneficiaries of the area expect and long for. The following are the benefits the team wants to highlight.

Employment Benefit

Since PCDF is one of the main sources of income of the many residents in Payatas, its closure brought families to be jobless and income-less. With the proposed infrastructures and facilities of the redevelopment plan, the residents will have opportunities for jobs that are related to agriculture and industry. The agro-industrial facilities will cater a lot of employees for its management and manpower, and at the same time will generate products that can be sold to the market, which will yield to more inflow of money.

Children

One of the prevalent issues that the Payatas community longs to be given a program to, is a program that will help their children. Though the researchers weren't able to conduct a focus group discussion or interview of the residents of Payatas to address what they really want, the team utilized existing studies that can be found. In a study by Bautista (2015), her interview with the Payatas residents highlighted that they want to address the lack of educational means for their children. Payatas residents highly value their children and believe that their children are the future. The team addressed this hope by adding educational facilities like the Eco-Museum and a playground area that will cater to the children's bright imagination and educational needs.

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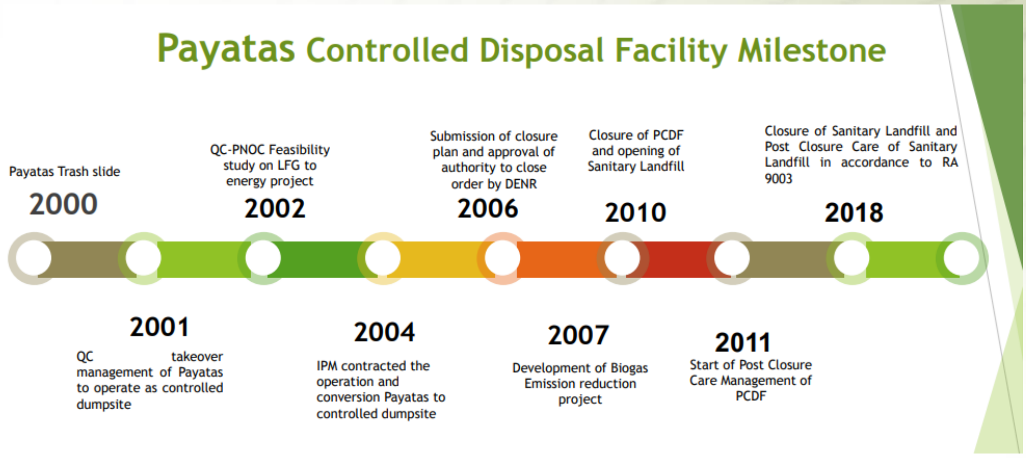

Annex 1. Payatas Controlled Disposal Facility Milestone

Luis Sabater
to Jodell, Crome, Costanza, Hélène, me
Tue, May 18, 11:39 PM (7 days ago)

Dear Sir Guinevere,

For your query no 1: attached is the photo that delineate the landfill and the controlled dumpsite. The landfill is approximately 7 hectares and the controlled dumpsite is about 23 hectares. The landfill has liner and ECC as per required by law.

For your query no 2: We do not have document to share the Post Closure Care Management, but basically, it is monitoring of the water, air and soil as well as the stability of the slopes and subsidence. It also consist of maintenance of slope, drainage system, soil cover, vegetation and the ancillary facility with in the disposal facility.

Engr. Louie S. Sabater, ASEAN Eng.
Planning Officer III
EPWMD

Annex 2. Information about controlled dumpsite and sanitary landfill

On Tue, May 11, 2021 at 6:07 PM Luis Sabater <louie26sabater@gmail.com> wrote:

Dear sir Edwin,

Regarding your queries for the Students Reinventing Cities Competition.

(1) For the leachate treatment of the disposal facility, the controlled dumpsite is employing the leachate recirculation method and phytoremediation method to treat the leachate. RA 9003 does not require leachate treatment for controlled dumpsite. For the sanitary landfill the developer is using Advanced Oxidation Process which is still under test-run stage.

Annex 3. Information about leachate system in PCDF

		Annual Average		
PARAMETERS	Standard Value	GW1	GW2	GW3
Arsenic	0.01	0.008	0.00825	0.008
Cadmium	0.003	0.001	0.001	0.001
Copper	1	0.003	0.003	0.0035
Lead	0.01	0.005	0.005	0.005
Manganese	0.4	3.12575	0.11075	0.06075
Zinc	5	0.0175	0.015	0.0095
Mercury	0.001	0.0002	0.00065	0.0002
Iron	1	0.8775	0.05875	0.03723
Selenium	0.04	0.01	0.01	0.00775
Total Coliform	1.1	8	8	8
Total Dissolved Solid	600	747.25	277.25	558.75
Nitrate	50	0.71375	3.4	3
Chloride	250	122.25	39.5	87.25
Sulfate	250	23.75	30.25	44
Hexavalent Chronium	0.02	0.002	0.002	0.002
Total Hardness	300	289	133.5	258

Annex 4. Groundwater values per site in 2020 provided by City

		Annual Average					
PARAMETERS	Standard Value	SW1	SW2	SW3	SW4	SW5	SW6
Aresenic	0.04	0.008	0.008	0.008	0.008	0.008	0.008
Cadmium	0.01	0.001	0.001	0.00325	0.001	0.001	0.001
Calcium	30	32.275	40.075	24.825	22.95	24.85	26.2725
Lead	0.1	0.0175	0.02125	0.005	0.005	0.005	0.005
Zinc	4	0.11375	0.04375	0.01875	0.04375	0.02875	0.02375
pH (range)	7.5	6.75	7.775	7.1	7.175	7.3	7.375
Color	150	68.75	300	34	95	95	61.25
BOD	15	197.5	93.5	27.75	174.5	49.25	25.25
COD	100	399.5	228.75	78.75	286.75	141.5	82.5
TDS	600	394.25	1039.75	329.75	507.75	461.25	390.25
TSS	110	207.25	75.25	27.25	141.5	98	29.5
Alkalinity	110	151.5	486.5	158.25	181.75	202.5	170.25
Ammonia	0.75	11.425	24.85	12.75	25.25	17.25	13.65
Hexavalent Chromium	0.02	0.002	0.00155	0.002	0.002	0.002	0.002
Total Phosphorus	0.1	2.875	2.35	1.925	4.125	2.875	1.46

Annex 5. Surface water values per site in 2020 provided by City

Annex 6. Groundwater and Surface water sites in PCDF

Annex 7. Proof of construction of sheet piles taken from Google Street View