IN-SITU WATER QUALITY AND ECONOMICAL LEACHATE TREATMENT SYSTEM FOR GOHAGODA DUMPING SITE, SRI LANKA

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ABSTRACT

Municipal solid waste (MSW) management and final disposal is one of the critical issues face by Local Authorities in Sri Lanka. Gohagoda, Kandy situated at Central Province of Sri Lanka, is one of the disposal sites, which has been used since 1960s for open dumping of municipal solid wastes with no treatment process in operation. Open dumping of solid wastes can cause detrimental impacts to groundwater, surface water, soil and air. Therefore, a proper landfill design and leachate treatment system is utmost important to prevent such impacts. This research was carried out to investigate water quality around Gohagoda dumping site and to design an economical leachate treatment system by estimating quality and quantity of leachate.

Using bore holes, shallow wells and drains, water sampling was carried out over 34 locations of the study area. GPS was used to position sampling locations. Timely variation of the water quality parameters such as BOD, COD, NO_3^-, NO_2^-, PO_4^{3-}, Na, K, Ca, DO, conductivity, pH and selected heavy metals of leachate, surface and ground water were measured at the surrounding area of the dumping site relate to weather conditions. Flow of leachate was measured during rainfalls and total flow was obtained using runoff model.

The analysis of water quality parameters showed that the surface water and groundwater around the dump site are highly contaminated. In addition, the results envisaged that the cause of contamination of water is the leachate of dumping site and consequently, leachate treatment is very essential to minimize the contamination of surface and ground water at surrounding area. Hence, a suitable hydraulic design for leachate treatment was introduced to reduce concentration of pollutants below the permissible levels. The propose treatment system consists of three principal unit processes such as biological treatment, activated carbon absorption unit followed by a construction wetland.

KEY WORDS: Gohagoda Dump Site, Leachate, Leachate Treatment System, Open Dumping, Water Pollution

1. INTRODUCTION

Generation of Municipal Solid Waste (MSW) and its management is becoming a major problem in developing countries. It increases with rapid urbanization and economic development due to the uncontrolled growth of population and its urban shift. Open dumping is used as an inadequate waste management practice of disposing solid waste, which is one of the cheapest, easiest methods and it requires less attention. In Sri Lanka, problems such as low technical standards of both collection and final disposal creating long term environmental and human health problems and this is aggravated due to absence of proper solid waste management system. Moreover, landfills without proper management and leachate treatment facilities become a prominent source of pollution that contaminates surface and ground water. Biogas, which are primarily compose of methane (CH_4), carbon dioxide (CO_2), hydrogen sulfide (H_2S), and other inert gases, are generated by the biological degradation of organic matter in landfills (Visvanathan, *et.al*, *2005*).

Open dumping of solid waste can cause injurious impact to groundwater, surface water, soil and air.

Further; it changes the ecological balance, pollutes the quality of air and creates ideal places for breeding of disease vectors. In the absence of technical methods to treat leachate, which migrate from the decomposing solid waste it percolates to the water bodies and sub soil. Accordingly generation of leachate has become one of the important problems associated to landfills of. Therefore, it is essential to treat the leachate to minimize the toxicity to living beings.

The city of Kandy in central Sri Lanka has a population of nearly 120,000. The last seat of the Sri Lankan Kings, a hill station and a UNESCO world heritage city, Kandy can be considered as the cultural and the spiritual capital of Sri Lanka. In addition to the residential population, a floating population of over 50,000 visits the city daily. These include the pilgrims that visit the temples, including the Sacred Temple of Buddha’s Tooth Relic.

The solid waste generated by all these inhabitants of the city is managed by the Kandy Municipal Council (KMC). The daily collection of solid waste in the city of Kandy exceeds 130 tones (Welikannage & Liyanage, 2009). The waste is presently dumped to the Gohagoda Solid Waste dump site, located near by the river Mahaweli, the main water source for the Kandy city. The method of disposal adopted by the KMC is simply dumping on to an open land without taking any measures to prevent or minimize hazards arising from dump waste. Therefore, this reduces scenic beauty and aesthetic value of the environment thereby creating negative visible impacts to human beings and can be badly affected for tourism, which is one of the main income sources in Sri Lanka.

1.1 Study area

The solid waste dumping site for Kandy city is situated at Gohagoda -Tekkawatta area at the North – West of Kandy city near Katugasthota and can be accessed by the Katugasthota – Peradeniya road. This site has been used since 1960s however; there is no treatment process in operation (Welikannage & Liyanage, 2009). The present dumping ground is about 3km away from the city limits, 6km from the Kandy city and at about 100m distance from the Mahaweli River.

1.1.1 Geology of the area

The main geological feature of Kandy city and its surrounding area is a band of marble one kilometer thick . This band is classified as coarse crystalline

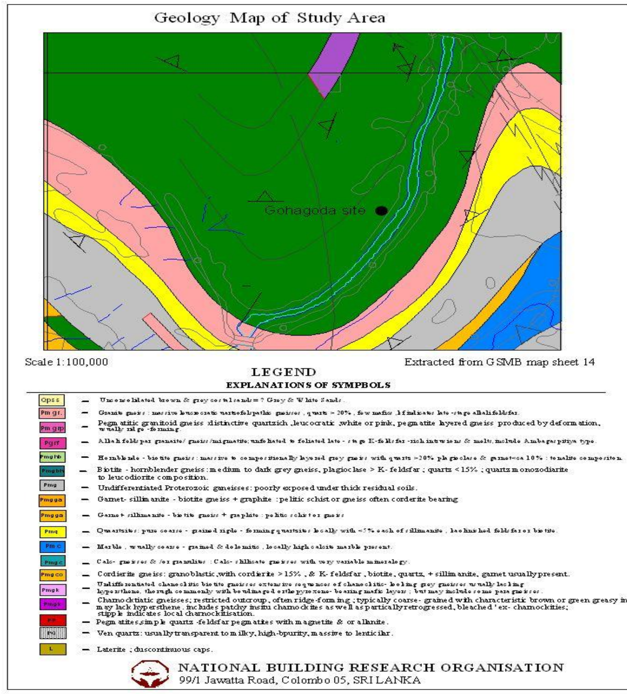

Figure 1.1- Geology map of the study area

mainly made up of Calaite. Calcsilicate gneiss intruded as bands within the host marble including scapolite and spinal as additional minerals. Collectively these two rock types give rise to red brown overburden latosolic soil that on average ranges in thickness from one to three meters. The major rock type identified is Biotite Gneiss, which cover almost half of the area. Homblende biotite gneiss, Garnet biotite gneiss and Granitic gneiss are also present in considerable percentages. Figure 1.1 shows the geology map of the study area while figure 1.2 shows its structural features.

1.1.2 Hydrogeology of the area

Groundwater in Kandy exists mostly in the form of semi confined aquifers in the first 100m of the bed rock. This groundwater exists both as small pockets of underground reservoirs and as fissure groundwater. The yields of these aquifers are not very well known and are limited as they recharge very slowly. In addition, there exist high-yielding groundwater resources along the alluvial flood plains of Mahaweli River that are mostly recharged by the river water (IEGS, 2007).

The general geographical and structural features are controlled by the geological discontinuities of the region. Furthermore ground water movements are also controlled by those structural features.

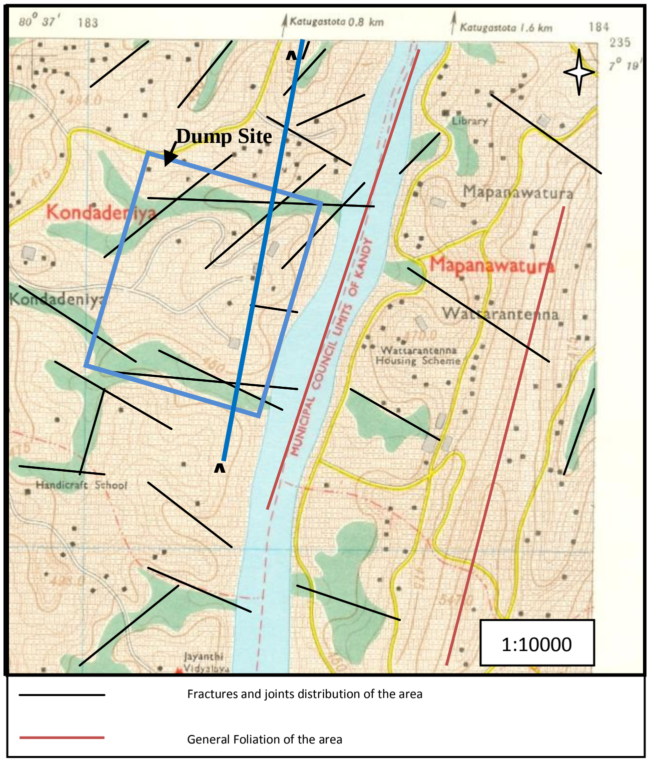

Figure 1.2 - Structural features of the study area

1.1.3 Climatic condition of the area

The city falls within the up country wet zone of Sri Lanka where the annual average rainfall is around 1905 – 3175mm. The main rainfall season is South – West monsoon. During the inter – monsoonal seasons, thunderstorm showers are frequent in the central island. Kandy has an average temperature level between the ranges of 21 – 26 ºC.

The Gohagoda dumping site causes surface and groundwater pollution as well as the accumulation and slower water flow in many drainage channels and provides breeding places for disease vectors such as rats and mosquitoes. Apart of that, during rainy periods, the runoff water takes solid waste from those dumping locations adds pollutants to natural water bodies such as Mahaweli River which is the longest river in Sri Lanka.

The rotten waste produces leachate and most of these are toxic and cannot be remove by using general treatments. There are some environmental, social and health problems due to the dump site. The leachates go along a drain and mixes with water in Mahaweli River, about 70m downstream from the intake of Greater Kandy Water Supply System.

Groundwater pollution originating from open dumping is badly affected to the aquifers and unable to use this water for people who live around this area. It is also observed that the soil contamination through direct waste contact or leachates or uncontrolled release of methane by anaerobic decomposition of waste and spreading of disease by different vectors. Toxicity to aquatic life and cows may be related either to acute or chronic effects on the organisms themselves or to humans by biological accumulation through food chains. Further, air pollution due to the presence of foul odor associated with open dumping and by burning of waste as well as due to release of green house gases from the dumping site.

Considering the above situation, it is awfully apparent that the Gohagoda dumping site needed an urgent rectification to protect surrounding surface and groundwater resource in order to protect public in the city of Kandy.

Therefore this research was carried out to investigate surface and groundwater quality around the Gohagoda dumping site and to carry out hydraulic design of an economical leachate treatment system.

2. LANDFILL LEACHATES

The term leachate refers to liquids that migrate from the waste carrying dissolved or suspended contaminants. Leachate is a high strength wastewater that contains high concentrations of organic matter and ammonium nitrogen which results from precipitation entering the landfill and from moisture that exists in the waste when it is disposed.

The composition of leachate varies greatly from site to site, and can vary within a particular site. Some of the factors affecting composition include age of landfill, types of waste, degree of decomposition; and physical modification of the waste (e.g.shredding) http://www.dwaf.gov.za/Documents/Policies/WDD/LeachateControl.pdf).

2.1 Generation of leachates

Rainfall is the main contributor to generation of leachate. The precipitation percolates through the waste and gains dissolved and suspended components from the biodegrading waste through several physical and chemical reactions. Other contributors to leachate generation include groundwater inflow, surface water runoff, and biological decomposition. Liquid fractions in the waste will also add to the leachate as well as moisture in the cover material (Abbas, 2009). Photo 2.1- shows that the generated leachate at Gohagoda Dump Site.

Fiugure 2.1- Generated leachate at Gohagoda Dump Site

2.2 Quality and quantity of the leachates

Mainly two different phases can be identified in landfills during the anaerobic decomposition of waste: acid phase, which causes a decrease of pH in the leachate but high concentrations of organic acids and inorganic ions (for e.g., Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+) and the methanogenic phase (Stegmann,2005). There are many factors affecting the quality of leachates; i.e., age of the dumping area/landfill, precipitation, seasonal weather variation, waste type and composition.

The quantity of leachtes are depend on rainwater percolation through wastes, biochemical processes in waste's cell, the inherent water content of wastes and its degree of compaction into the landfill tip. The production is generally greater whenever the waste is less compacted; since compaction reduces the filtration rate. Leachate production is the result of precipitation, evaporation, surface runoff, infiltration, waste storage capacity etc.

2.3 Composition of leachate

The composition of the landfill leachate varies greatly depending on the age of the landfill. As landfill age increased, organic concentration (COD) in leachate decreased and increase of ammonia nitrogen concentration. The existing relation between the age of the landfill and the organic matter composition may provide useful criteria to choose a suited treatment process (Amalendu, 2004). Bagchi (2004) has tabulated the range of concentration of different parameters in leachate of municipal waste which is shown in table 2.1. The table describes the lower limits and upper limits that can be expected from the landfill leachates.

Table 2.1. Range of concentration of different parameters in leachate of municipal waste

Parameter	Range of concentration
TDS	584 – 55,000 (mg/l)
Specific Conductance	480 – 72,500 (µmho/cm)
TSS	2 – 140,900 (mg/l)
BOD	ND – 195,000 (mg/l)
COD	6.6 – 99,000 (mg/l)
TOC	ND – 40,000 (mg/l)
pH	3.7 – 8.9 (units)
Total alkalinity	ND – 15,050 (mg/l)
Hardness	0.1 – 225,000 (mg/l)
Chloride	2 – 11,375 (mg/l)
Calcium	3 – 2,500 (mg/l)
Sodium	12 – 6,010 (mg/l)
Total Kjeldahl nitrogen	2 – 3,320 (mg/l)
Iron	ND – 4,000 (mg/l)
Potassium	ND – 3,200 (mg/l)
Magnesium	4 – 780 (mg/l)
Ammonia - nitrogen	ND – 1,200 (mg/l)
Sulphate	ND – 1,850 (mg/l)
Aluminum	ND – 85 (mg/l)
Zinc	ND – 731 (mg/l)
Manganese	ND – 400 (mg/l)
Total Phosphorous	ND – 234 (mg/l)
Nickel	ND – 7.5 (mg/l)
Nitrate - nitrogen	ND – 250 (mg/l)
Lead	ND – 14.2 (mg/l)
Chromium	ND – 5.6 (mg/l)
Copper	ND – 9 (mg/l)
Cyanide	ND – 6 (mg/l)
Nitrite - nitrogen	ND – 1.46 (mg/l)
Cadmium	ND – 0.4 (mg/l)
Mercury	ND – 3 (mg/l)
Turbidity	40 – 500 (Jackson units)

ND-Not Detected
(Source: Bagchi, 2004)

Therefore, production of leachate is an important problem associated to landfills and it needs to be pre-treated on site to meet the standards for its discharge into the sewer or its direct disposal into surface water.

3. METHODOLOGY

In order to achieve the objectives, the following methodologies were adopted. The topography of the area was identified by using contour maps and places are selected for boreholes. The water table around the site is monitored by using selected boreholes and shallow and deep wells. The drainage paths from site to surface water bodies were identified and water sampling was carried out over 34 locations of the study area. Figure 3.1 shows the borehole locations at Gohagoda dump site.

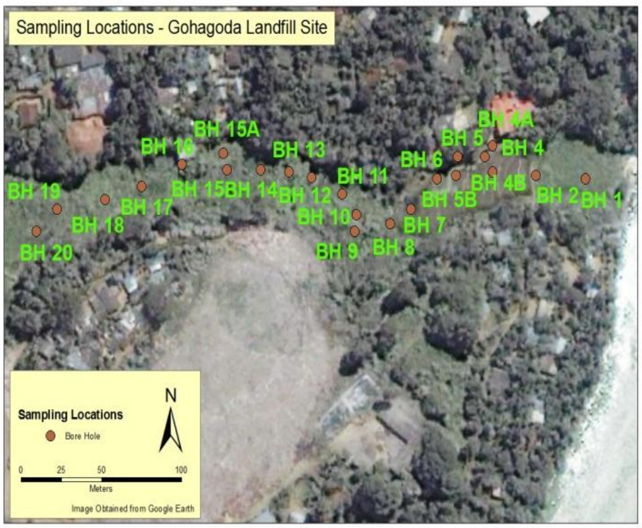

Figure 3.1. Borehole Locations at Gohagoda Dump Site

According to the hydrogeology of the study area it is proved that the fractures and joints distribution go along the paddy-field and ends with the Mahaweli River. Therefore locations of the boreholes were selected due to slope direction and geological structure and its special features of the study area. Figure 3.2 and table 3,2 show the water and leachate sampling locations at the dump site.

When water sampling, shallow wells around the area were used to collect groundwater while surface water was collected from Mahaweli River. Leachate was collected from four locations L1-L4 at dump site area while treated water was collected from Greater Kandy Water Supply System, during wet season. In-situ measurements of water quality parameters were taken for temperature, pH, Total Dissolved Solids, Conductivity and Dissolved Oxygen were checked by using the Digital pH meter, Digital Temperature/ TDS/ Conductivity meter and Digital DO meter respectively. Nitrate, Nitrite, Phosphate, and Sulphate were measured by using Spectrophotometer (HACH DR/2010). Heavy metals such as Fe, Cu, Pb, Cd, Mn, Cr, Zn and Mg and cations (K, Na, Ca) were checked by using Atomic Absorption Spectrophotometer.

Table 3.1 – Details for Borehole locations

Borehole	Depth(mm)	GPS Coordinates	
		X (E)	Y (N)
BH 1	4515	001-83-697	002-34-721
BH 2	2930	001-83-666	002-34-723
BH 4A	2590	001-83-639	002-34-739
BH 4	3240	001-83-634	002-34-733
BH 4B	3320	001-83-639	002-34-725
BH 5	3300	001-83-617	002-34-733
BH 5B	1280	001-83-616	002-34-723
BH 6	1160	001-83-604	002-34-721
BH 7	660	001-83-588	002-34-705
BH 8	740	001-83-575	002-34-697
BH 9	1965	001-83-553	002-34-693
BH 10	1540	001-83-554	002-34-702
BH 11	575	001-83-545	002-34-713
BH 12	845	001-83-526	002-34-722
BH 13	1925	001-83-512	002-34-725
BH 14	640	001-83-494	002-34-726
BH 15A	1735	001-83-471	002-34-735
BH 15	1120	001-83-473	002-34-726
BH 16	1435	001-83-445	002-34-729
BH 17	120	001-83-420	002-34-717
BH 18	470	001-83-397	002-34-710
BH 19	1860	001-83-367	002-34-705
BH 20	660	001-83-354	002-34-693

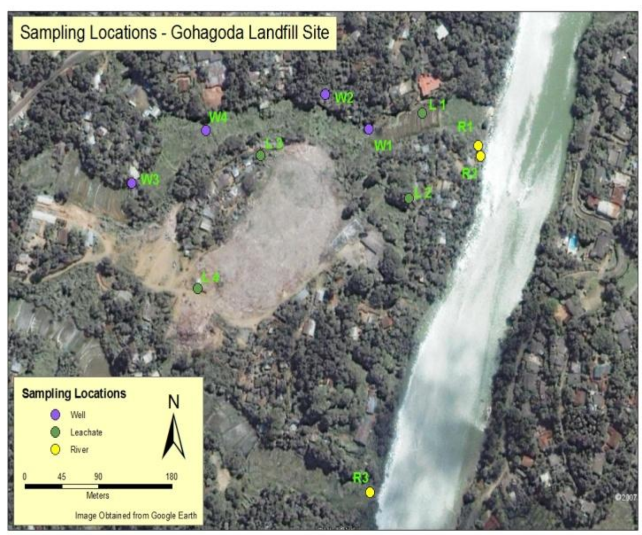

Figure 3.2. Water and leachate sampling locations at Gohagoda Dump Site

Table 3.2 Details of sampling positions

Sampling position	GPS Coordinates	
	X (E)	Y (N)
W 1	001-83-577	002-34-710
W 2	001-83-523	002-34-746
W 3	001-83-286	002-34-654
W 4	001-83-377	002-34-709
R 1	001-83-711	002-34-693
R 2	001-83-714	002-34-682
R 3	001-83-578	002-34-332
L 1	001-83-642	002-34-727
L 2	001-83-626	002-34-638
L 3	001-83-444	002-34-683
L 4	001-83-367	002-34-544

W – Well R – River, L – Leachate

4. RESULTS AND DISCUSSION

4.1 Quality of leachate verses rainfall intensity

This study shows that the rainfall affects to changes of water/leachate quality. During rainy weather conditions the water/leachate becomes diluted and it also reduces the contaminant levels. In this study water samples were collected weekly to analyze and observe the variation of contaminant levels with rainfall.

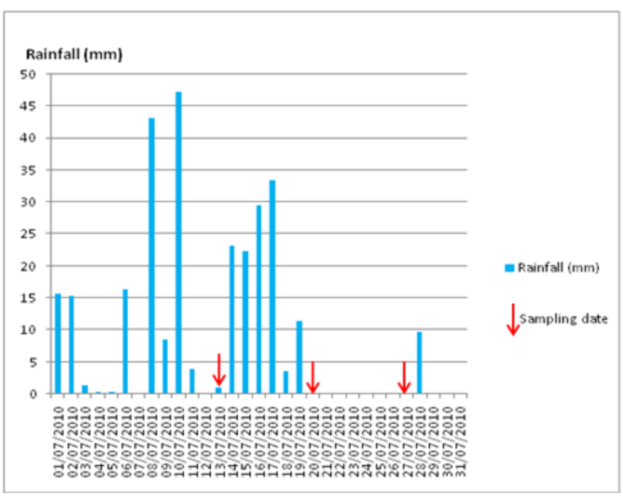

Figure 4.1 Daily rainfall intensity variation around Katugastota area.

The variation of the daily rainfall intensity of the Gohagoda, Katugastota area during the period of July 2010 is collected from the Department of Meteorology, Sri Lanka.

Different types of parameters of water and leachate samples measured and most affected parameters obtained. The results showed that the parameters such as Sulphate, Copper and Zink which are almost within the permissible level but the parameters such as Lead, Chromium, Magnesium, Potassium and Calcium exceed the permissible levels in different locations with the rainfall.

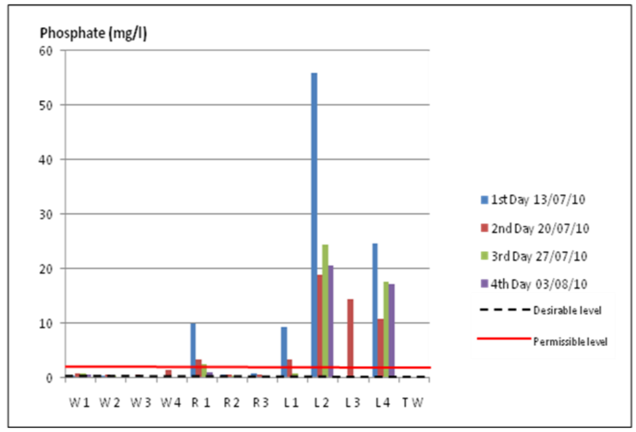

Figure 4.2 Analysis of phosphate for collected samples

The concentration of Phosphate of the leachate varies from place to place. The highest value of PO_4^- (55.9mg/l) was recorded at the L2 in day1, while the lowest value of 0mg/l is obtained at the L1 at day 4. It is clearly showed that the concentration of Phosphate is extremely high in leachate samples. This is a serious issue as high concentration of Phosphate causes eutrophication as well as accelerates the growth of algae.

4.2 GIS mapping

According to the test results the water and leachate quality analysis reveal that the pollution of surface and groundwater around the dump site. The ArcGIS software was used to represent the test results as it provides clear observation for complex information and also it helps to organize and centralize data. Further it provides excellent support for environmental assessment, water quality monitoring and etc.

GIS map for pollutant levels of conductivity around the Gohagoda dump site is shown in the Figure 4.3, which clearly indicates that the concentration varies within a wide range for leachate samples and most of the area is highly polluted.

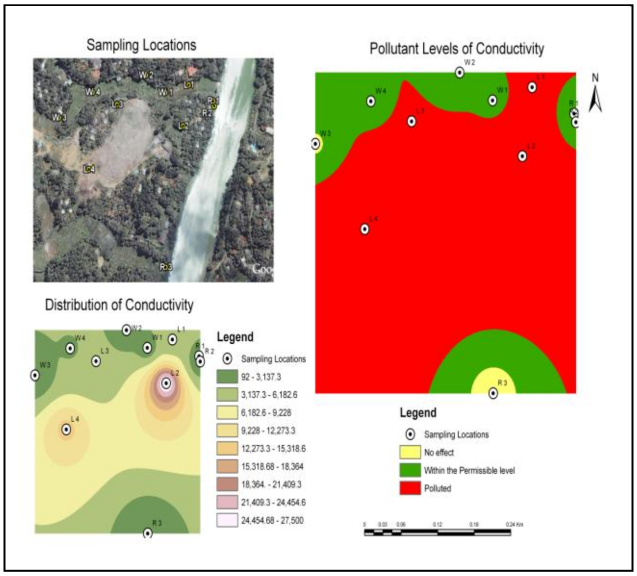

Figure 4.3 GIS map for pollutant levels of conductivity around the Gohagoda Dump Site

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Table 4.3.The summary of leachate quality at the Gohagoda dumping site.

Parameter	Test Results (Max^m value of leachate)	Permissible level
BOD (mg/l)	20000	30
COD (mg/l)	48000	500
Conductivity (µS/cm)	27500	3500
Nitrate (mg/l)	63.6	10
Nitrite (mg/l)	1.938	0.01
Phosphate (mg/l)	55.9	2
Iron (mg/l)	7.9	1
Cadmium (mg/l)	0.1	0.005
Manganese (mg/l)	1.93	0.5
Sodium (mg/l)	9199.53	100
DO (mg/l)	0.07	>8
Lead (mg/l)	0.09	0.05
Chromium (mg/l)	0.08	0.05
Magnesium (mg/l)	445.31	150
Potassium (mg/l)	3411.4	8
Calcium (mg/l)	640	240

The highest value is obtained at the L2 with the value of 27500µS/cm whereas the lowest value is obtained at the R3 with the value of 39µS/cm. The high conductivity value obtained for the groundwater and leachate near the landfill and it indicates that the landfill is directly affected to the leachate and groundwater quality. The results reveals that the leachate consists with high amount of mineral salts.

Table 4.3 shows the maximum values of leachate quality at the dumping site. The results clearly provide the evidences of that all parameters mentioned are extremely higher than the permissible levels stipulated by Sri Lankan Standards Institute. Hence it is obvious that the importance of leachate treatment to minimize further pollutions.

5. LEACHATE TREATMENT DESIGN

There are several wastewater treatment methods available in the world such as biological treatment, physical/chemical treatment, adsorption, ammonium stripping, chemical oxidation, ion exchange, electrochemical treatment, reverse osmosis etc. By considering the advantages and disadvantages of those treatment methods, as well as quality and quantity of leachate biological treatment followed by activated carbon adsorption and construction wetland was proposed as the most economical treatment system.

5.1 Collection of leachate

In general, generated leachate goes out from the bottom end of the dump and surface runoff goes along the surface of the dump.

The leachate that moves down through the solid waste in the landfill site is first filtered as it passes through the crushed stone and the sand layer. This leachate is collected by perforated leachate collection pipes due to gravity.

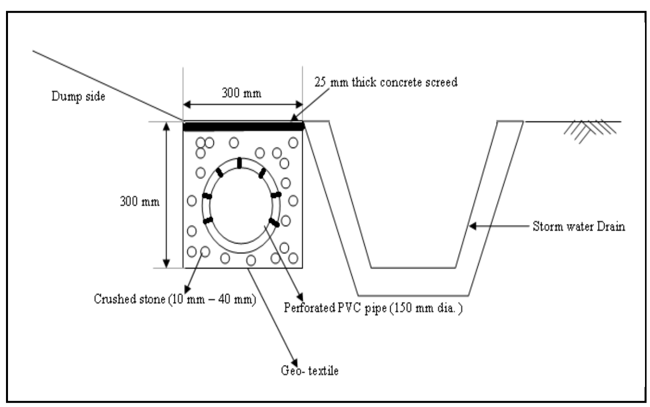

Figure 5.1 Details of the leachate pipe line

Design details of the leachate pipe line is shown in the figure 5.1. The diameter of 150 mm perforated pipe was proposed to collect generated leachate and the crushed stones are used to filter the leachate to avoid the solid impurities which block the holes around the PVC pipe.

5.2 Biological leachate treatment process

Biological purification process is classified as aerobic or anaerobic depending on whether or not the biological processing medium requires an oxygen supply (Abbas *et al*, 2009). Due to its reliability, simplicity and high cost-effectiveness, biological treatment (suspended/attached growth) is commonly used for the removal of the bulk of leachate containing high concentrations of BOD. When treating young (biodegradable) leachate, biological techniques can yield a reasonable treatment performance with respect to COD, NH3–N and heavy metals (Kurniawan *et al*, 2005).
Based on the estimations, conventional plug flow was selected as the activated sludge process. Figure 5.3 shows the schematic diagram of proposed conventional plug flow. This system includes three principal units' namely primary settling tank, aerator and secondary settling tank.

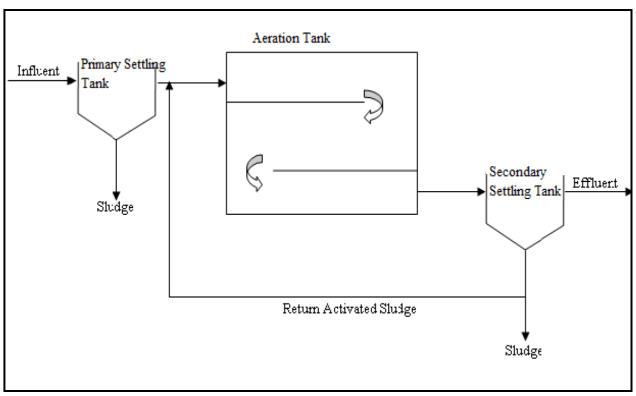

Figure 5.1 Schematic diagram of conventional plug flow in the proposed treatment system

Primary settling tank is a simple settling tank and normally rectangular or circular shape. This unit can be used to remove a large portion of suspended material, which is preliminary inorganic in nature. Efficiently designed and operated primary settling tanks generally removes 50% to 70% of suspended solids and from 25% to 40% of BOD.

The aeration system is designed for the activated sludge process must be adequate to satisfy the BOD and TSS of wastewater. For this design "jet" type of device was proposed to use for aeration. In jet devices compressed air injected into mixed liquor as it is pumped under pressure through jet device.

The main purpose of providing the secondary settling tank is to separate the large volume of suspended solids coming from activated sludge reactor (Aeration tank) and to obtain very clear and stable effluent having low concentration of BOD and SS.

5.2.1 Design Considerations

Design considerations used for this study to design biological treatment units were adopted from Met Calf & Eddy (2003).

- Total leachate flow = 30000m^3/year
- Maximum BOD of leachate = 20000mg/l
- Total Suspended Solids = 68mg/l
- BOD removal at primary settling tank = 25%
- TSS removal at primary settling tank = 50%
- F/M ratio = 0.2 – 0.4
- MLSS = 2000mg/l
- Organic Load = 0.3 – 0.7 kg/m^3/day
- Oxygen Transfer Efficiency = 15%
- Oxygen percentage in air = 23.2%
- Specific weight of the air = 1.201 kg/m^3

The dimensions of the biological treatment units are shown in Table 5.1.

Table 5.1 Dimensions of the biological treatment units

Unit	Nos	Dimension
Primary settling tank	1	Length=19.5m Width=6.5m Depth=2.6m
Aeration tank	2	Length=36m Width=7.2m Depth=3.6m
Secondary settling tank	2	Length=30.7m Width=6.2m Depth=3.1m

5.3 Activated carbon adsorption column

In general, leachates may also contain a high concentration of metals and some hazardous organic chemicals. A significant portion of the landfill leachate is contributed by the inorganic constituents which comprising of the ions such as Calcium, Magnesium, Sodium, Potassium, Ammonium, Iron, Manganese, chlorides, Sulphates and Bicarbonates coupled with heavy metals such as Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Mercury, Nickel and Zink which are readily soluble at fixed concentrations during the degradation processes (Foo & Hameed, 2009).

Due to migration of leachate; soil, groundwater and surface water have been contaminated with heavy metals and lead to serious problems. It is envisaged that the main sources of heavy metals in the dumping site are pharmaceuticals, personal care products, fluorescent tubes, waste oil, batteries, electronic waste, electrical equipments, paints and etc. generated at the household and the community.

Though, removal of heavy metal can be achieved through various techniques adsorption using activated carbon, proposed to this system because activated carbon too shows high metal adsorption capacity similar to alumina, silica and ferric oxide (Mohan and Gandhimathi, 2009).

5.3.1 Landfill leachate treatment via activated carbon adsorption process

There are some inherent physical properties of activated carbon such as large porous area, controllable pore structure, thermo stability and low acid/base reactivity. Therefore it has a superior ability for removal of wide variety of organic and inorganic pollutants dissolved in aqueous media, even from gaseous environment (Foo & Hameed, 2009).

Foo & Hameed (2009), have been evaluated some removal efficiencies of organic, inorganic constituents and heavy metals, when activated carbon was used. According to their study COD , NH_3-N, heavy metals such as Cu, Pb, Cd, Mn, Cr and Zn remove by 91%, 19%, and 80-96% respectively. Hence this study too can be expected the similar removal efficiencies and therefore suggested series of activated carbon columns to employ in this level to reduce the concentrations to permissible levels.

5.4 Construction wetland

Wetlands are simply habitats with permanent or temporary accumulation of water with associated floral and faunal communities (Kotagama and Bambaradeniya, 2009).Wetlands offer a biologically diverse ecosystem capable of removing many contaminants found in water. Wetlands can be used for mechanical removal of suspended solids through sedimentation, dissolved nutrients, biochemical oxygen demand, heavy metals and potentially harmful anthropogenic compounds geochemical and biological processes (Williams & Adamsen, 2008).

There are some evaluations about the removal efficiencies of parameters in wetland such as conductivity (53%), DO (58%), SS (36%), Ca^{+2}, $SO4^{2-,}$ Cl^{-} , Na^{+} (34 %), NO^{2-} (75%), $NO^{3-(}$68%), BOD (66%), COD (72%) and etc (Maine *et al.*, 2007). Therefore normally metal concentrations were significantly lower in the effluent than he influent because of the higher removal efficiency.

Maine *et al.,* (2007) showed that in a wetland normally the length to width ratio should be 5:1 and retention time to be from 7 to 12 days. Hence this study also adopted the similar values to carry out the hydraulic design. To enhance the impermeability of the bottom layer, a betonies liner will be introduced to reach a hydraulic conductivity of $10^{-7}ms^{-1}$ (5 compacted layers of bentonite, approximate total depth: 0.6 m). A layer of 1 m of soil is placed on top of the bentonite layer. This study recommend that to plant locally available macrophyte species can be transplanted in the wetland (Figure 5.4) and the waste water is passed through it, until the treated effluent is discharged into the water source.

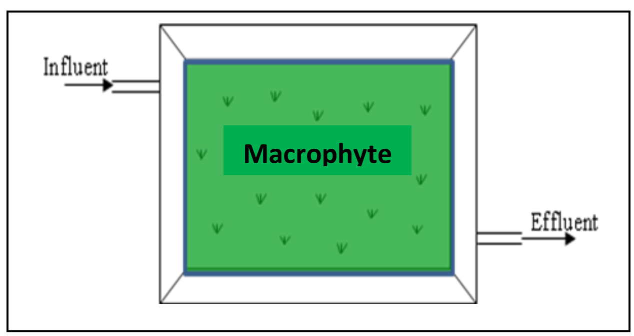

Figure 5.4 – Proposed construction wetland

6. CONCLUSIONS

The concentration of eleven heavy metals: Cadmium, Calcium, Chromium, Copper, Iron, Magnesium, Manganese, Potassium, Sodium, Zink and lead are found in the leachate of Gohadoa dumping site. Suspended solids, Turbidity, COD and Conductivity, also were well above the permissible levels of in surface and groundwater in the surrounding area. The results show that the constituent characteristics of Municipal Solid Waste is a major factor influenced on leaching solutions and heavy metal release. The concentration of heavy metals and other physical parameters are higher during the dry weather condition than the wet weather condition. Therefore it is revealed that higher rainfalls enhance heavy metal release through the leachate from the dump site to the surface and groundwater bodies around the Gohagoda Dumping site.

Furthermore, the geological features are also in favor to the transport leachate to the Mahaweli river, which is the principal water source of the Kandy City. Therefore leachate treatment is very essential to minimize the contamination which can be achieved through the proposed hydrological design.

By considering all the facts, it is recommended the proper landfill design is needed to the area and the leachate treatment through the proposed design has to be adopted without delay.

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