Leachate Quality Analysis and Passive Treatment Options

Pema Choden

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“I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.”

Signed

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Abbreviations, Acronym and Symbols

Abbreviation	*Term*
SWM	Solid Waste Management
MSW	Municipal Solid Waste
SWMC	Summerhill Waste Management Centre
AWQGFMW	Australian Water Quality Guidelines for Fresh and Marine Waters.
BOM	Bureau of Meteorology
RGoB	Royal Government of Bhutan
BFS	Blast Furnace Slag
GAC	Granular Activated Carbon
PAC	Powdered Activated Carbon
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TOC	Total Organic Carbon
XOCs	Xenobiotic Organic Compounds
OM	Organic Matter
NCM	Non-compostable Materials
TKN	Total Kjeldahl Nitrogen
SRP	Soluble Reactive Phosphorus
$\mathbf{K_{sat}}$	Saturated hydraulic conductivity (permeability)
$\mathbf{D_{10}}$	Effective size of filter material finer by 10%
LEL	Lower Explosive Limit
kL	Kilolitre
EC	Electrical Conductivity
pH	measure of H^+ activity
UMR	Under Measuring Range
NA	Not Applicable

P	Phosphorus
CH_4	Methane
CO_2	Carbon dioxide
NH_3	Ammonia
$CaCO_3$	Calcium Carbonate

Abstract

More than 90% of municipal solid waste (MSW) in developing countries is disposed of in landfills. In Bhutan, about 90% of solid waste is disposed of in landfills. One of the significant problems associated with landfills is the generation of leachate. Landfill leachates are highly contaminated waste waters containing high concentrations of organic matter (OM) measured as biochemical oxygen demand (BOD) and chemical oxygen demand (COD), ammonia, halogenated hydrocarbons and trace elements. The direct release of leachate into the environment may pose potential risks and hazards to public health and ecosystems. As a result, cost effective and environmentally acceptable treatments of leachate are sought. This research aims to examine leachate characteristics and two low cost passive treatment options.

The characteristics of a typical leachate generated at a modern sanitary landfill were investigated by analysis of long-term monitoring data collected at Summerhill Waste Management Centre (SWMC), Newcastle, NSW. Leachate production from the SWMC landfill was clearly related to rainfall events at the landfill site. Rainfall has a direct impact on the volume of leachate produced and consequently on its chemical characteristics. Thus, leachate treatment systems must have provisions for the variation in concentrations.

The primary goal of this study was to investigate the suitability of two low cost passive leachate treatment options, which are viable and suitable for adoption in Bhutan. Two laboratory bench scale experiments were undertaken. The first experiment involved surface aeration of raw leachate over a period of 20 days, while the second investigated the treatment performance of three low cost filter media (Granular Activated Carbon (GAC), Blast Furnace Slag (BFS) and sand) by examining their sorption efficiencies in a series of column experiments. Leachate samples were collected from the landfill at SWMC.

The results of the research showed that a medium strength landfill leachate can be treated by both methods to reduce the concentrations of certain parameters. Aerobic treatment enhanced the leachate quality mainly through removal of ammonia and OM (>95%). It resulted in significant pollutant reductions as opposed to no aeration, which resulted in anoxic conditions. Column experiments provided leachate treatment essentially by lowering soluble reactive phosphorus (SRP) concentration. BFS and GAC have performed comparatively better with P-removal efficiencies of 92% and 67%, respectively, than sand (40%) in the laboratory work undertaken.

Finally, the research results also suggested landfills in Bhutan do not have appropriate leachate and gas collection facilities. Due to a lack of proper waste segregation, the leachates produced in landfills could be chemically complex. Composting is suggested as a sustainable alternative for SWM in Bhutan to reduce the 50-60% of organic waste disposed of in the landfills if leachate collection and treatment cannot be afforded.