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STUDY OF LEACHATE AND WASTE COMPOSITION AT DIFFERENT LANDFILL SITES OF NEPAL

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ABSTRACT
This article focuses on the types of waste composition coming to landfills of different ages and waste feeding amount and leachate characteristics (BOD_5, COD_{cr}) of those landfill sites. The study was carried out at different age of landfills namely: Sisdole (Kathmandu), Pokhara and Karaute Dada (Dang) landfill sites of Nepal. The waste composition was studied onsite and collected leachates from the landfill sites were analyzed for their composition. The organic component of waste were found high as 61.6%, 52.5% and 65% at Sisdole, Pokhara and Karaute Dada landfill sites respectively. The age of the landfills and waste composition have a significant effect on leachate composition. It was observed that the fresh leachate has relatively high amount of BOD_5 and COD_{cr}. Those landfills with high percentage of organic content have higher value of BOD_5 and COD_{cr}.

KEYWORDS: Landfills sites, Leachate, Organic waste

INTRODUCTION
In Nepal, especially in urban cities and metropolitans, solid waste management is a major environmental concern. Main issues of solid waste problems in Kathmandu Metropolitan and other major cities are - inadequate collection system, public attitude, lack of sanitary landfill sites for the safe disposal, political intervention and conflicts among stakeholders. Solid waste management has traditionally been a distinctly municipal responsibility in Nepal. The in-effective governance of the authorities responsible for solid waste management has led to the presence of significant amounts of unmanaged waste in cities around the country. Rapid and unplanned urban growth has exerted tremendous pressure on the urban environment and solid waste is visibly the worst environmental problem in many urban areas in the country (Thapa et al., 2009).

The environmental problem caused by improper solid waste management in the expanding cities is one of the most urgent issues for the government of Nepal. Leachate from a landfill varies widely in composition depending on the age of the landfill and the type of waste that it contains. It can usually contain both dissolved and suspended material. The generation of leachate is caused principally by moisture content of waste, biochemical reactions and precipitation percolating through waste deposited in a landfill. Once in contact with decomposing solid waste, the percolating water becomes contaminated and if it then flows out of the waste material it is termed leachate (http://en.wikipedia.org/wiki/Landfill). The problem created by the leachate that generates from the landfill is one of the challenges for the surface and ground water contamination. This study examines the composition of waste dumped in Sisdole, Pokhara and Karaute Dada (Dang) landfill sites and their characteristics in relation to the age of landfills and organic content in the waste.

STUDY SITES:

This study evaluates the following sites:

Sisdole landfill site: The landfill site (LFS) was constructed under supervision, both technical and economical, by Japan International Co-operation Agency (JICA) in June 2005. The purpose of the Sisdole LFS was to serve as short-term disposal site while other options were investigated. The life span of the LFS was planned for 2-3 years (Thapa et al., 2009). At Sisdole LFS waste from Kathmandu metropolitan city (KMC) and Lalitpur sub-metropolitan city (LSMC) is treated. Additional waste deposition has been doing after adding structures to receive more wastes. The LFS covers a total area of 15 ha of which 2 ha is the actual landfill area. 13 ha is occupied for protection and buffer zones, access and internal services roads, administration facilities and leachate treatment plant (Khanal et al., 2009). The landfill consists of two valleys. The first valley is 11200 sq. meters with a volume capacity of 166085 cum and second valley is 9501 sq. meters with a volume capacity of 108910 cum (Kathmandu Metropolitan City, 2011). Valley 2 is closed 22 months ago and valley 1 is in operation. Since the LFS has been used for a longer time than predicted it is causing several problems and public opposition among the local people living in the area nearby the LFS exists. Local protests and roadblocks are a frequent feature.

Leachate treatment unit: The design leachate quantity is 45 cum/day for the retention time being 7 days. The leachate from the landfill is collected in a leachate retention pond of volume 408 cum and surface area of 334 square meters. The pond has a depth of 1.25m with the maximum leachate retention level at a depth of 1.25m below the invert level of leachate outlet pipe, so that fresh air can easily pass through the pipe opening into the waste layers. The pond is lined with 2 layers of 350 micron HDPE sheet covering all surfaces and is bordered at the top of its embankment along all four sides with stone masonry work which not only increases its retaining capacity beyond the overflow level, but also fixes the plastic sheet in position. The leachate is aerated in a pond through aerator system which is a floating type slow speed surface aerator of 15 HP (11kW approx) and is regarded as biological aerobic system (Khanal et al., 2009). The aerated leachate is then re-circulated by means of recirculation pump of capacity 5 kilo-watt which is a long portable flexible hose pipe of 175m length and 80mm diameter. The sprinkler used for the spraying of re-circulated leachate over waste cells is a perforated PVC pipe of 80mm diameter. At present, both the aerator and recirculation pump is not in function due to lack of operation and maintenance and insufficient electric supply in the country.

Pokhara sanitary landfill site: Pokhara LFS is located approximately 6 km outside of Pokhara Sub-Metropolitan Corporation (PSMC) in ward 18 in the vicinity of Seti River. The LFS was constructed on 1997-2003 and has been in operation since 2004. The total area of thelandfill site is 10 ha, with 4 ha for landfilling, 1.5 ha forleachate treatment facility. 3.75 ha of buffer zone, internal road and other infrastructure and 0.75 ha of compositing unit, yet to be commenced. The terrain longitudinal slope along east to west is of about 2% andabout 3% along north to south (Pokharamunicipality, 2011).

Leachate treatment unit: Reed Bed treatment system is being used for the treatment of leachate and septage in Pokhara LFS. It uses the hybrid form of Reed Bed System with intermittent tank before both of the reeds, i.e. horizontal and vertical. The area of the HRB and VRB is 1105 m^2 and 2203 m^2 respectively. The designed flow of leachate is 40m^3/day and that of municipal septage is 75 m3/day, which is not in operation these days. The base of HRB has a 1% longitudinal slope and a 2% transverse slope in two ways. The base of VRB has only 1% longitudinal slope. The treated leachate after reed bed treatment system is then diluted by the surface water overflow of the surface water collection basin before discharging to the Seti River.

Karaute Dada sanitary landfill site: This LFS is located at Gorahi municipality ward No 9 of Dang district. This LFS is 1 km away from the settlement area. The total area of landfill site is 20 ha. Only 1 ha land has been utilized for waste management while rest of the land is used for fruits and tree plantation. The landfill site shall not be considered a sanitary landfill site as the landfill site is not engineered, though there is the provision of waste segregation house, composting unit and collection house of plastic and paper. No liners and perforated pipes are used at the landfill site (Gorahi municipality, 2011).

Leachate treatment unit: Leachate Treatment Plant is constructed at the base of old valley used for the waste disposal which is full now. It has a sedimentation tank of

size 10x10x2 cum. It was followed by 2 filtration chambers of size 10x3x2 cum and 10x2x2 cum respectively followed by disinfection chamber of 2x2x1.82cum which is discharged through the drain.

Table No: 1 Summary of study LFSs

LFS	Leachate Treatment System	Construction	Operation	Current Age (intermediate)	Design Capacity	Current feeding rate to LFS
Sisdole	Leachate collection pond with semi aerobic recirculatory system and floating type slow speed surface aerator	1992 July	2005 June	8 years (intermediate)	280 tons/day	390 tons/day
Pokhara	Constructed wetland	1997 Dec	2004 Jan	9 Years (intermediate)	120 tons/day	78 tons/day
Karaute Dada	Filtration with disinfection	2001 June	2005 may	8 years (intermediate)	10 tons/day	7.2 tons/day

METHODOLOGY

Sampling: Waste composition study and leachate samples were collected, on March 1st , April 1st and May 1st , 2013 10% of the vehicles coming to landfill sites were considered and sample of about 100 kg waste from each vehicle was taken. 12 compactor trucks were taken in Sisdole, 5 in Pokhara and 2 in Karaute Dada LFS. The samples were put on the plastic mat so that no wetting effect was observed. Segregation was done and the percentage of the waste composition was determined.

For the leachate study, 1 litre leachate from the leachate collection pond of each sites (five samples from each sites) were collected on the plastic bottle for three months. Collected leachate were preserved and taken to the pollution control lab, Kathmandu University for the analysis as per standard method, APHA (2012).

Composition study of the waste: Composition study of the waste was done using the waste reduction method. In this method, the sampled waste was divided into four quarters, from which, one diagonal is taken and remaining diagonal is removed. The wastes were segregated as organic waste, plastics, paper, glass, rubber/leather, textile, metal, construction and demolition and others.

Leachate Analysis: From the leachate collected, pH, BOD_5 and COD_{cr} were determined by using the standard methods.

RESULTS AND DISCUSSION

The waste composition percentage in the studied sites is shown in figure 1.

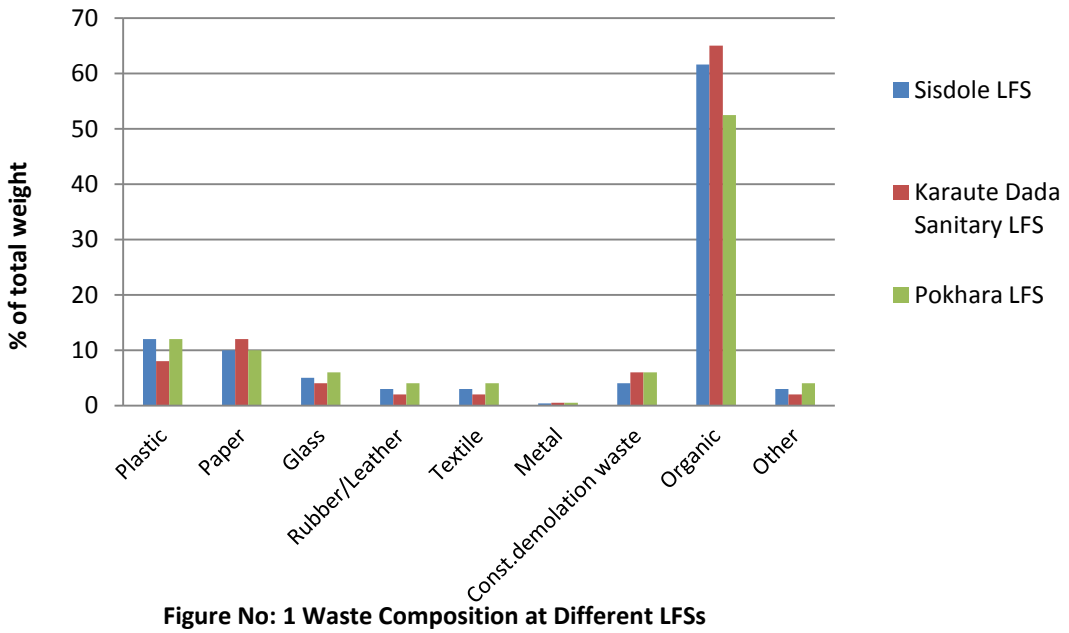

Figure No: 1 Waste Composition at Different LFSs

Table No: 2 Leachate characteristics at different landfill sites

	Sisdole LFS	Karaute Dada LFS	Pokhara LFS
pH	7.7	6.9	6.5
BOD_5 (mg/l)	2560	1020	1120
COD_{cr}(mg/l)	23000	9140	9188
BOD/COD	0.11	0.11	0.12

The figure shows that the percentage of organic content of solid waste is relatively greater in all three landfills with the least percentage of 52.5% at Pokhara LFS to 65% in Karaute Dada and 61.6% in Sisdole LFS. The percentage composition of plastic ranged from 8-12, paper 10-11.5, glass 3-6, rubber 2-4, textile 2-4, metal 0.4-1.5, construction demolition 4-6 and others 2-4. Glass, plastics, rubber, leather and textile were relatively higher in composition at Pokhara LFS. This may be due to the fact that larger number of tourists at the city consuming more packed foods and the living standard of the people in Pokhara is also high than that of the other area. Organic, plastic and paper content of the waste are higher at all the landfill.

In table 2, the BOD_5 values for leachate at sisdole, Pokhara and Karaute Dada LFSs are 2560, 1120, and 1020 mg/l respectively. The COD_{cr} values for the same study sites were recorded as 23000, 9140, 9188 mg/l for Sisdole, Pokahar and Karaute Dada LFS respectively. pH is generally slightly acidic expect in sisdole LFS which is towards basic as the waste is more stabilized. BOD_5 varies according to age of LFS, amount of waste feeding and composition of solid waste. Although the BOD_5 and COD_{cr} are almost similar in Pokhara and Karaute Dada, Sisdole has high value of BOD_5 and COD_{cr} as the rate of waste feeding in this LFS is much larger than those of Pokhara and Karaute Dada LFSs. All the study LFSs are within the age of 7-9 years. For the intermediate age of LFS (5-10 years) the values for the BOD is 400-3000 mg/l (Ainee and Aziz 2012). The value of the BOD in this study is consistent with those published by other researchers. In this study, the BOD_5/COD_{cr} ratios for the collected leachate samples ranged between 0.11-0.12. The BOD_5/COD_{cr} ratio describes the degree of biodegradation and gives information on the age of a landfill. The low ratio shows the high concentration of non-biodegradable organic compounds and thus difficulty to be biologically degraded (Ainee and Aziz 2012) including that the landfills are relatively young.

CONCLUSIONS

The present study concludes that the waste compositions in all sites are largely similar, though Pokhara has relatively lower organic content. The leachate characteristics follow the pattern observed in other landfill sites of intermediate age. Leachate pH of sisdole was relatively higher (7.7) than the rest with 6.5 and 6.9. Semi aerobic landfills tends to have relatively higher pH value (Bashir et al 2010). BOD_5 and COD_{cr} are almost similar in Pokhara and Karaute Dada. But in Sisdole high value of BOD_5 and COD_{cr} is recorded as the rate of waste feeding in this LFS is much larger than those of Pokhara and Karaute Dada LFSs. The low BOD_5/COD_{cr} ratio shows the high concentration of non-biodegradable organic compounds and thus difficulty to be biologically degraded and landfills are relatively younger.

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