Assessment of Groundwater Quality due to Leachate Generated from a Solid Waste Dumpsite

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Abstract: *In Sri Lanka, one of the main sources of groundwater pollution is the leachate generated from solid waste dumpsites. Karadiyana landfill is located 2km from Ratmalana airport, which receives nearly 500 tons of Municipal Solid Waste (MSW) daily. There is a considerable number of wells in the surrounding area, which are being used for drinking and other domestic purposes. The main focus of this study was to identify whether there is any effect of leachate on groundwater in nearby areas of Karadiyana dumpsite. Thus, well waters in nearby areas of the Karadiyana Dumpsite were collected. Subsequently, parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Phosphates and Ammoniacal Nitrogen included in these groundwater samples were determined. After the obtained concentrations were compared with permissible standards for drinking water, it was identified that some of the groundwater samples contained several contaminants exceeding the permissible limits. Moreover, the effect of distance on the degree of leachate contamination was also determined. Accordingly, it was suggested to identify the causing grounds for the anomaly obtained in these outcomes. As the conclusion, it was determined that for the time being, there is no significant effect of leachate on groundwater within the area starting from 400m away from the Karadiyana Dumpsite.*

Keywords*: Groundwater pollution, dumpsite, solid waste disposal, leachate, contamination*

1. Introduction

As a consequence of population growth and urban development in developing countries, the rate of waste generation is increasing significantly. Most commonly, Municipal Solid Waste consists of everyday items that people throw after use such as batteries, electrical appliances, paint, glass, plastics, papers and food waste. Since Sri Lanka is a developing country, majority of MSW consists of food wastes, yard wastes and plastics. MSW, which includes these various constituents has a considerable degree of negative impact on environment and human health.

Out of numerous waste disposal practices such as incineration, waste compaction and thermal treatment plants, Sri Lanka uses open ground waste dumping method. Since aforementioned methods require more land and more technology for their operation, open ground waste dumping method is the waste disposal technique widely used in Sri Lanka(Dharmarathne and Gunatilake, 2013). The collected wastes are usually dumped in uncontrolled dumping grounds near residential buildings(Eseyin and Osu, 2019). This technique is more likely to be remain in Sri Lanka for a long time, since it seems to be one of the cheapest methods of waste disposal. Despite the fact that dumpsites are being used for waste management purposes, a huge number of adverse effects, especially for the neighbouring population of the dumpsite can be identified.

The adverse effects of dumpsites can be indicated as a main source of pollution of groundwater, surface water and soil, due to leachate contamination(Mishra et al., 2019).

Generation of leachate results, when dumped solid wastes comes in contact with groundwater or rain water. In view of this, it could be said that leachate is any liquid that passes through the dumped waste, while extracting the soluble or suspended solids and any other component present in it. Then, the leachate contaminated groundwater flows away from the dumpsite and get mixed with groundwater resources in the surrounding area of the dumpsite making those water resources polluted too('No Title', 1972). Leachate may contain high amounts of toxic substances including organic, inorganic and heavy metallic components. Due to leachate entering into subsoil and lastly into groundwater resources, groundwater of neighbouring areas of the dumpsite may become unsuitable for human consumption. But, the extent of effect of leachate contamination of groundwater resources depends on several factors including the depth of the water table, groundwater flow direction and concentration of contaminants(O et al., 2011).

Conventionally, when dumping wastes beforehand the ground should be prepared with necessary liners to prevent infiltration of leachate to groundwater or it is more effective to have a leachate collecting system. Introduction of a proper leachate controlling method to maintain leaching at the lowest level possible, is the primary method to protect surrounding water resources from leachate contamination(Przydatek and Kanownik, 2019). Accordingly, leachate can be properly collected and treated before disposing in to ecosystems.

As groundwater can be observed as a primary source of water supply in developing nations, this leachate contamination could lead to very critical environmental and health issues in Sri Lanka. Many researchers have conducted studies to determine the effect of leachate on groundwater and have identified that both groundwater and surface waters get polluted by leachate. Meanwhile it seems obvious that the damage cause to groundwater resources in developing countries is considerably at a higher degree as a result of uncontrolled or semi-controlled open dumps. In addition to that, disposal of hazardous wastes along with MSW can be identified as another reason which increases the threat to groundwater resources in such countries.

This study was based on Karadiyana Dumpsite. It is a semi- controlled dumpsite which has been identified as one of the largest dumpsites in the country. Karadiyana dumping ground is situated in Thumbovila village in Western province, Sri Lanka. Nearly 575 tons of MSW is dumped to the dumping ground daily(Koliyabandara et al., 2017). The dumpsite has existed for over 30 years. The wastes from Panadura, Dehiwala, Kesbawa, Boralasgamuwa, Kotte and Mount Lavinia are dumped there. In addition, there is a compost plant which has been constructed as a solution for this huge amount of waste dumped in the dumping site.

2. Metodology and Data

A. Selection of Locations to Collect Samples

In order to proceed the study, the area within 1km distance from Karadiyana dumpsite was divided into five regions having 200m intervals. From all the wells located within 1km radius of Karadiyana dumpsite, several wells were randomly selected to collect the groundwater samples. These samples were collected in such a way that it covers the whole perimeter included in 1km radius.

Figure 1. Considered regions around the dumpsite

Source:<https://www.mapdevelopers.com/draw-circle-tool.php>

B. Sample Collection

Three samples from each selected well were collected, with the purpose of obtaining a mean value for the analysed parameters.

Transportation and Storage of Groundwater Samples Samples were collected into brown coloured bottles, in order to prevent the contaminants from breaking down. All the collected samples were stored in a cooler box until they were delivered to the laboratory. The reason for that was to prevent bacteria from multiplying inside the collected samples.

C. Execution of Laboratory Tests

All the collected samples were evaluated for physical and chemical characteristics including pH, TDS, EC, concentration of Total Phosphates and concentration of Ammoniacal Nitrogen.

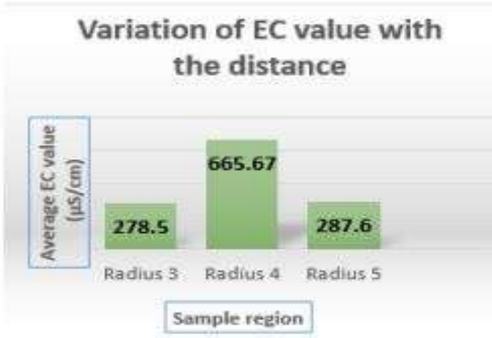
3. Results and Discussion

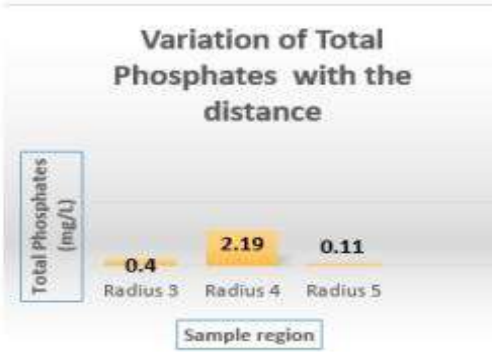
A. Groundwater Characteristics

1) Variation of Groundwater Quality Parameters: The tested samples' pH values were between the range of 5.30 and 8.30. This indicates that tested water samples were varied from acidic to basic in nature. However, as per the specified requirement indicated in the first revision of SLS 614:2013-Specification of Potable Water, the majority of the pH values of the samples were within the allowable limits. TDS values for the samples that were examined ranged from 74.9 mg/L to 645.9 mg/L. Only one of the tested samples, from the fourth region, fell beyond the 500 mg/L TDS maximum permitted value given in the first revision of SLS 614:2013-Specification of Potable Water. Furthermore, it is evident from the results, that the samples taken from the fifth region have comparatively low TDS values.

All of the values obtained for electrical conductivity (EC) were less than 950 µS/cm. However, only one sample taken from the fifth region had an EC reading of 580 µS/cm, which was above the limit permitted. With the exception of the aforementioned sample and the water samples taken from the fourth region, all the other samples had EC values below 400 µS/cm, the upper limit specified by the World Health Organization (WHO). Additionally, the data clearly indicate that the samples collected from the fifth region have relatively low EC values.

However, results for the samples' Total Phosphates concentration were found to range from 0.07 mg/L to 5.6 mg/L. With the exception of one sample taken from region 4, none of the other samples were found to contain more total phosphates than its permissible amount, which is 2 mg/L in potable water.





Moreover, the concentration of ammoniacal nitrogen was found in the samples tested for the study to be between 0.1 mg/L and 4 mg/L. After analysis of the results, the concentration of ammoniacal nitrogen in half of the examined samples was found to be higher than the maximum allowable value, which is 0.5 mg/L according to the National Academy of Science.

Additionally, the samples taken from the fifth region exhibited the lowest ammoniacal nitrogen concentration values.

Table 1. Results for Groundwater Characteristics

Sample name		Parameter				
		pH	TDS (mg/L)	EC (μS/cm)	Total Phosphates (mg/L)	Ammoniacal Nitrogen (mg/L)
Radius 3	Sample 1	5.30	168	223	0.6	0.2
	Sample 2	7.26	235.2	334	0.2	0.27
Radius 4	Sample 1	8.30	415	649	5.6	4
	Sample 2	7.00	285.3	424	0.09	3.5
	Sample 3	7.39	645.9	924	0.88	0.55
Radius 5	Sample 1	7.50	289	580	0.2	1.5
	Sample 2	5.63	74.9	111.3	0.07	0.1
	Sample 3	5.72	110.6	171.5	0.07	0.11

2) Effect of Distance:

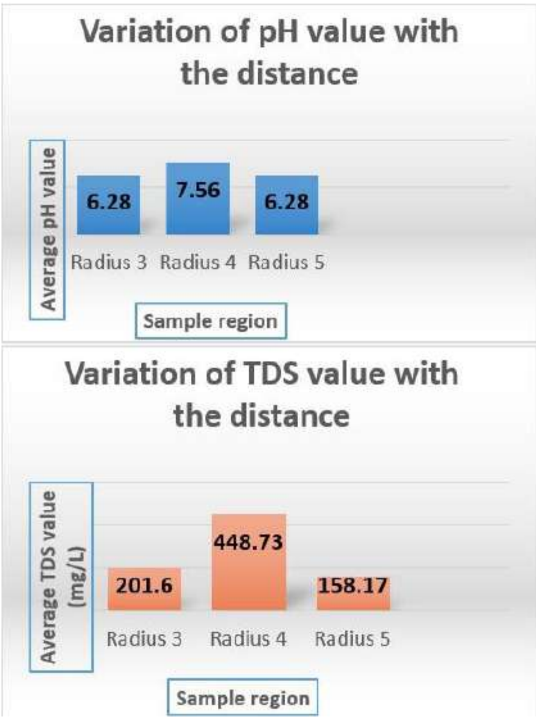


Figure 2. Variation of Parameters with the Distance

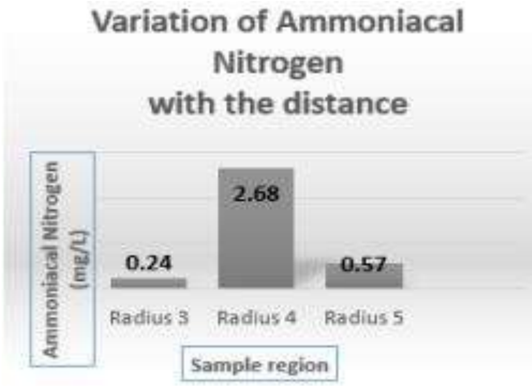


Figure 3. Variation of Parameters with the Distance

The results demonstrate that region 4 (radius 4 / R4) samples have greater average concentrations of all parameters than the other 2 regions. However both regions 3 and 5 have obtained the same average pH value. But, the average pH value determined from the samples from regions 3 and 5 indicates a value that is significantly below the acceptable pH level for drinking water. Waters in those places can be regarded of as being naturally more acidic because they have a low pH value.

When taking into account the TDS concentration results, it is clear that the samples taken from region 5, which is the location farthest from the dumpsite, generated the lowest value. This demonstrates the idea that leaching's impact tends to reduce with increasing distance from the dumpsite. However, based on the results, it can be determined that the average EC value of the samples that were collected from region 4 deviates significantly from those of the other two regions.

Furthermore, samples from region 5 have a lower average concentration of total phosphates than samples from region 3, which is much closer the dumpsite. The average concentration of Total Phosphates in samples from Region 4 is higher than that of the other two regions, and this value can be considered to be higher than the recommended concentration for drinking water. When comparing groundwater samples collected from regions 3 and 5, the results for the average concentration of ammoniacal nitrogen exhibit relatively low values compared to those collected from region 4.

The results were expected to vary, with samples taken from regions 3 to 5 providing the concentration of water quality parameters in descending order. However, based on the results, there was a significant departure from the predicted results in the parameter concentrations of the samples collected from region 4. There are two possible explanations that could be used to justify the observed deviations:

- In region 4, there might be companies or production plants that discharge wastes that could degrade the quality of the groundwater in wells.
- Aquifers that are directly associated to the Karadiyana dumpsite may be found in the wells that were used for the study in region 4.

3) Groundwater Suitability: The SLS 614: 2013- Specification for Potable Water (First Revision)(For, 2013) specifies the following aloowed maximum limits for each evaluated parameter.

Table 2. Specification for Potable Water

Characteristic	Maximum permissible requirement
pH	6.5 to 8.5
Electrical Conductivity (EC)	400 µS/cm
Total Dissolved Solids (TDS)	500 mg/L
Total Phosphates	2.0 mg/L
Ammoniacal Nitrogen	-

Since there is no maximum permissible value for the concentration of Ammoniacal Nitrogen given in the SLS 614: 2013 – Specification for Potable Water (First Revision), the acceptable standard value given for that was identified as 0.5 mg/L according to the National Academy of Science('No Title', 1972).

The average values of the tested parameters for each chosen location were taken into consideration in order to evaluate the appropriateness of the groundwater in the study area. However, the pH values for regions 3 and 5 exceed the acceptable limit for drinking water when the range in mean pH values of the samples is taken into account. Despite having a noticeably high value, the mean TDS value in region 4 is below the maximum limit for drinking water. Thus, it is possible to determine that the well waters in these 3 regions are acceptable for drinking purposes on the basis of the concentration of TDS values.

However, when comparing the mean EC values for these three regions, samples from region 4 have a high value that is higher than the standard EC limit for drinking water. This clarifies the fact that the well waters of region 4 are not directly suitable for consumption.

Based on the results for the concentration of Total Phosphates, samples from regions 3 and 5 mainly contained negligible levels. However, the total phosphate concentration of the wells in region 4 remained higher than the allowable limit, rendering the water in that area unsafe for residential use.

Based on the discussion above, it could be determined that the well water in region 4 is not at a level that is suitable for human consumption.

4. Conclusion and Recommendation

Based on the results, it can be concluded that the leachate produced by the Karadiyana dumpsite appears to have a minimal effect on the quality of the groundwater in the vicinity, beginning 400 meters away from the dumpsite. However, it was also observed that some of the groundwater samples exhibited abnormal levels of Total Phosphates, Ammoniacal Nitrogen, and Electrical Conductivity. This could be an indication that the leachate produced in the landfill may have collected over time in certain locations of the study area to some extent.

Furthermore, as the majority of the tested parameters were beyond the permitted limits specified by the SLS 614: 2013 Specification for Potable Water (First Revision), it has been concluded that the groundwater from wells in region 4 is not appropriate for immediate drinking.

However, over the time, threats to groundwater in these areas may increase due to leachate generated in Karadiyana dumpsite. Therefore, the need of enhancing waste management techniques can be identified as a very important measure in this regard. Conducting laboratory tests for water quality analysis in coming years may also help to identify the state of these groundwater. Additionally, further studies should be conducted in order to justify the reasons for the obtained anomaly in the results. It is also recommended to upgrade the Karadiyana dumpsite to a modernized dumpsite, with the purpose of restricting the generated leachate from mixing with groundwater resources.

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