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Geo-environmental sampling: How good is a good practice?

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Abstract: Sampling procedures and strategies should be designed to meet the objectives of each specific investigation upon which an effective risk assessment has to be made to the impacts of waste disposal sites on the local environment. In this respect, extensive and comprehensive information has been extracted from the literature, which we hypothesize it can improve the quality and representativeness of geo-environmental samples, which are collected for chemical analysis. The main interference problems, which are encountered during sampling activities, are pointed out. Sampling procedures for soil, groundwater, surface water, and leachate are discussed in detail. It is found that the variations in procedures of sample preservation, storage and handling are attributed relatively to the media of sampling and parameters required for intended analysis.

INTRODUCTION

Sampling is the selection of representative portion of a larger population, universe, or body to characterize a hazardous waste site accurately so that its impacts on human health and the environment can be properly evaluated. Through the examination of the sample, the characteristics of the larger body from which the sample was drawn can be inferred. In this manner (USEPA, 1994a), sampling can be a valuable tool for determining the presence, type and extent of contamination by hazardous substances in the environment.

According to Ehrig (1983), landfill leachates contain a variety of contaminants including heavy metals usually found at moderate concentration in municipal landfill leachates. Part of the variation seen among landfill leachates is due to differences in waste composition and landfill technology, but part of the variation may also be attributed to the lack of standard protocols for sampling, filtration and storage of leachate samples. However, Grounaris *et al.* (1993) noted that concentration of metals measured in a leachate sample might depend strongly on the amount of colloidal matter presents in the sample and the handing of the sample.

Waters are susceptible to change as a result of physical, chemical or biological reactions, which may take place between the time of sampling and the analysis. However, if precautions are not taken, at the time of sampling, changes may occur rendering analytical data unrepresentative; on the other side, the storage temperature, exposure to light, the nature of the containers used and the time between sampling and analysis will affect these changes (Dryden Aqua Ltd., 2000).

The choice of a soil sampling method, according to (Minnesota Pollution Control Agency, 1998), is based on many reasons including accessibility, cost, soil conditions and type of data desired.

The purpose of this paper, therefore, is to discuss standard procedures to be applied during collection of geo-environmental samples for investigating inorganic pollutants, which are migrating from landfill sites into soil and ground water. This information may have implications for sampling of soil, ground water, surface water and leachates for the fate of heavy metals in the landfill leachates in the environment.

GEO-ENVIRONMENTAL SAMPLING PROBLEMS

In general, environmental conditions, or non-target chemicals may cause problems and /or interference when performing sampling activities or when sampling for a specific parameter. There are many different potential problems associated with geo-environmental sampling, vary relatively according to media of sampling and equipment used. These problems result in introducing of foreign contaminants into a sample. However, these can be avoided by following strict sampling procedures.

Two primary potential problems associated with soil and surface water sampling processes are cross contamination of samples and improper sampling collection. Samples cross contamination can be eliminated or minimized through the use of dedicated sampling equipment, otherwise, decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of matrix, resulting in compaction of the sample or inadequate homogenization of the samples, where required, resulting in variable, non-representative results (USEPA, 1994a).

Surface water, however, affected significantly by disturbance of stream or impoundment substrate and sampling in an obviously disturbed area (USEPA, 1994b).

Field personnel can compromise the analysis of ground water in two primary ways, by taking an unrepresentative sample, or incorrect handling of the sample (USEPA, 1995).

British Department of Environment (1994), reported that sampling strategies for ground water need to take account of the nature of the water contamination, which is often an unknown, the geology and hydrogeology, including the likely direction of groundwater flow and potential migration pathways. Water sampling requires considerable care and attention, as there are many factors, which affect the quality of the recovered samples. In particular borehole waters will be affected by the extent to which drilling fluids have been introduced into the borehole, and in sampling wells, the possibility of ingress of surface waters down the installation (Prince *et al.*, 1996).

Samples of hazardous materials may pose a safety threat to both field and laboratory personnel. Precaution then should be implemented when handling these types of sample (USEPA, 1994a).

SAMPLING PROCEDURES

The sample must remain chemically stable until it can be analyzed and must not be cross-contaminated during and after sampling. However, it is recommended using new, clean containers since the use of recycling containers can lead to inadvertent cross-contamination, particularly from contaminants, which adsorb onto the container walls. There are three reasons for conducting soil sampling in order to (1) evaluate potential human and health ecological risks on the site and in vicinity of the property in question, (2) to determine the potential for soil contaminants to leach into ground water, and (3) to assess the need and extent of potential remedial actions (Minnesota Pollution Control Agency, 1998). Collection of samples from near surface can be accomplished with tools such as spades, shovels, trowels, and scoops. Tools plates with chrome or other materials should not be used. However, this method can be used in most soil types but is limited to sampling at or ground surface. Bucket type augers, on the other hand, are better for direct sample recovery because they can provide a large volume of sample in short time (USEPA, 2000). However, thin-wall tube sampler is used in conjunction with bucket auger to collect minimally undisturbed samples (ER, 2000).

Soil samples are commonly collected as disturbed samples either in plastic bags, tubs or in glass jars which are suitable for all types of analysis. However, to avoid cross-contamination, it is common practice to clean boring tools by means of pressure washers or stream cleaners, more usually between sampling locations, but occasionally between samples from one location (Scottish Enterprise, 1993).

To obtain a representative ground water sample for chemical analysis it is important to remove stagnant water in the well casing and the water immediately adjacent to the well before sample collection. At least three well volumes should be purged and the equipment must be decontaminated prior to use and between wells. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed (USEPA, 1995). There are many devices of different characteristics used to collect ground water samples. However, it may be appropriate using a device to sample different than that, used to purge. The most common example of this is the use of a submersible pump to purge and bailer to sample (USEPA, 1991).

When using auger to drill boreholes for ground water sampling, casing should always be used during the drilling of investigation borings. This due to the fact that these borings are deeper and that satisfactory sampling is usually the objective, either soil or water or both. The use of casing will prevent cross- contamination between various strata and it is also necessary when drilling below ground water level (Danish EPA, 2002).

Purging is the process of removing stagnant water in a well immediately prior to sampling. However, it is recommended removing three well water volumes to assure stabilization of ground water chemistry, which can be evaluated by measuring the pH, temperature and specific conductivity as water is withdrawn from the well (RRC, 2001).

USEPA, (1995), developed the following formula in order to ease calculation the well water volume:

$$\text{Well volume} = \pi r^2 h \text{ (cf)}$$

where π = radius of monitoring well (feet);
h = height of the water column (feet);
cf = conversion factor (gal/ft^3)
(in this equation, 7.48 gal/ft^3).

According to USEPA (1994b), sampling of both aqueous and non-aqueous liquids from streams, rivers, lakes, ponds, lagoons and surface impoundments, is generally accomplished through using one of the following samplers or techniques:

1. Kemmerer bottle: used in most situations where site access is from a boat, bridge, or pier, and where samples at depth are required.
2. Bacon bomb sampler: of the same function as Kemmerer bottle.
3. Dip sampler: is useful in situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited.
4. Direct method: utilized to collect water samples from the surface directly into the sample bottle. This method is not recommended for sampling lagoon or other impoundments where contact with contaminants is a concern.

Mainly types of parameters required for chemical analysis determine the procedure for leachate sampling, which must be designed in a way that ensures that sample chemistry, is maintained as closely as possible to in situ conditions. It is preferable, however collecting leachate samples from their point of first emergence and points around leachate source (e.g. drainage system) if any.

Table 1. Soil sample handling modified from Danish EPA, (2002).

Substance	Packing	Transportation & Storage	Storage life
Degradable / Unstable: Phenols, Mercury, Chrome (IV), Cyanides	Glass with airtight lids, i.e. diaphram or Redcap, duran jars, jam jars	Cool and dark, at 4°C	24 – 48 hrs
Stable Substances: Heavy metals	Jam jars Nylon bags	No particular requirement, though cool and dark storage is preferable	1 month

Table 2. Water sample handling (source: Minnesota Pollution Control Agency, 1998). P = polyethylene.

Parameter	Bottle	Filling method	Preservation	Holding time
Major and Minor ions	1 l P	No head space	Cool	28 days
Nitrate	250 ml P	Leave head space	H_2SO_4 / pH<12 Lab, cool	28 days
Cyanide	500 ml P	Leave head space	NaOH / pH>12 Lab, cool	14 days
Trace Metals (unfiltered) (Mercury)	500 ml P	Leave head space	HNO_3 / pH<2 Lab, cool	6 months (28 days)
Trace metals (filtered) (Mercury)	500 ml P	Filter [0.45 micron] Leave head space	HNO_3 / pH<2 Lab, cool	6 months (28 days)
Chromium4 (unfiltered)	125 ml P	No head space	Cool	24 hours
Chromuim4 (filtered)	125 ml P	Filter [0.45 micron] No head space	Cool	24 hours
Miscellaneous (TDS and TSS) (Specific conductance) (Turbidity)	1 l P	No head space	Cool	7 days 28 days 48 hours
pH, alkalinity, dissolved oxygen, Eh	(2) 1 l P	Fill from bottom (don't filter for pH) Filter [0.45 micron]	Cool	2 hours
Total phosphorous	125 ml P	Leave head space	H_2SO_4 / pH<2 Lab, cool	28 days

SAMPLE HANDLING AND PRESERVATION

Soil samples taken for chemical analysis must be packaged in a way that ensures minimum changes during transport and waiting time. Chemical preservation of solids is not generally recommended. Samples should, however, be cooled and protected from sunlight to minimize any potential reaction (USEPA, 2000). Table 1 shows the required packing, transportation, storage and storage life for the soil sample relative to the parameter(s) for which a sample being collected.

Type of analysis (USEPA, 1982) for which water sample is being collected, determines the type of bottle, preservative, holding time and filtering requirements. British Standards Institution (1996), recommended a variety of techniques for stabilization of water samples, by means of temperature control or addition of fixing agents such as acids or alkalis, and it is common practice to filter samples prior to stabilizing the water so that dissolved contaminants are analyzed. Table 2 shows the recommended bottles, preservatives and filling methods required for each parameter, however, the holding time starts from time at which sample being collected (Minnesota Pollution Control Agency, 1998).

CONCLUSION

The recent rapid growing-up sense of environmental conservation all over the world requires a significant improvement in the quality of geo-environmental sampling and how representative it is. In this concern, most of geo-environmental sampling procedures, which have been adopted by U.S. Environmental Protection Agency and some European Environmental Agencies, are standard and capable for all circumstances. Nevertheless, some attention should be paid to the environmental and climatic conditions and the choice of equipment of sampling. However, it is a good practice to avoid circumstances under which the probability of cross-contamination occurrence may significantly increase, in particular, regarding soil and ground water sampling.

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