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Technical note

# Electrokinetic geosynthetic dewatering of nuclear contaminated waste

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ABSTRACT

Nuclear facilities produce both high level and low level contaminated wastes. The latter may relate to the civil infrastructure of the site and include waste sludge accumulating in drainage facilities. Over time the volume of the contaminated sludge can become significant requiring treatment and long term storage. If the waste is a liquid or near liquid form dewatering the waste is a requirement before deposition in a storage facility. However, dewatering using conventional methods usually results in an increase in volume of material which needs to be stored. The use of electrokinetic geosynthetics (EKG) technology provides an alternative dewatering treatment method which reduces the volume of the contaminated waste. The paper describes the dewatering of nuclear contaminated waste sludge using electrokinetic geosynthetics bags.



## 1. Introduction

Nuclear facilities produce both high level and low level contaminated wastes. The latter may relate to the civil infrastructure of the site and include waste sludge from water treatment and wastes or sediment accumulating in drainage facilities. Over time the volume of the contaminated sludge can become significant requiring removal, treatment and storage in special long term facilities.

If the material is in a liquid or near liquid form (sludge) it has to be dewatered or changed to a solid before deposition. However, dewatering using conventional methods is frequently difficult. A common method of treatment before storage is to add inert material such as cement as a means of creating a solid residue. The result of this approach is to increase the volume of contaminated waste which needs to be stored. This can have financial implications. The use of electrokinetic geosynthetic (EKG) technology has been shown to be an effective alternative method of treatment which is rapid, inexpensive and has the major advantage of reducing the volume of waste which needs to be stored.

This paper provides a brief description of the EKG concept and electrokinetic dewatering techniques and describes how the method is used to dewater nuclear contaminated waste sludge at an established nuclear facility in the United Kingdom.

## 2. Electrokintetic geosynthetics (EKG)

Conventional geosynthetics play a *passive* role in ground, mining or waste engineering; for example, geosynthetic drains provide a passage for water but do not cause the water to flow to the drain. The scope of geosynthetic applications can be extended if they can provide an *active* role, initiating biological, chemical, or physical changes to the matrix in which they are installed as well as providing the standard geosynthetic functions. This can be achieved by combining electrokinetic phenomena with the traditional functions of geosynthetics of drainage, filtration, containment, and reinforcement to form electrokinetic geosynthetics (EKG). Thus an EKG drain provides a drainage function but also causes the water to flow towards the drain.

EKG technology works by harnessing electro-osmosis, which is the water flow that occurs in response to an imposed voltage gradient. In fine-grained materials such as sludge, electro-osmosis can achieve flow rates of up to four orders of magnitude greater than hydraulic flow, Fig. 1. In addition, EKG materials can be used to control the physical, chemical, and electrical boundary conditions. Details of the development of EKG technology and its applications have been described by Jones et al. (2008).

The method of application of electrokinetic dewatering depends upon the nature of the material to be treated, Table 1. Table 1 shows the potential electrokinetic treatment methods available using different EKG dewatering materials. The applicability of the different methods depends upon the volume and uniformity of the material to be treated and the rate of supply, Table 2. Thus, the

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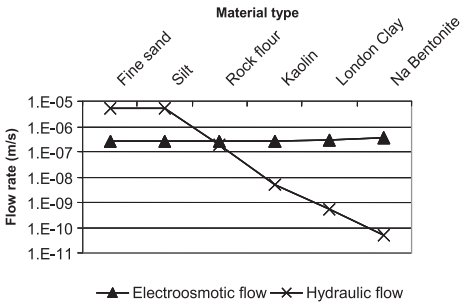


**Fig. 1.** Comparison of electrokinetic and hydraulic flow in different materials.

**Table 1**
Conceptual application of EKGs for water reduction in tailings, slurries and sludge.

| Material | Liquid/ sludge | Sludge/ paste | Solid/ cake | Improved solid |
|---|---|---|---|---|
| EKG Applications | EKG belt press | | | |
| | | ePD(*in-situ*) | | |
| | EKG bags | | | |

dewatering of mine tailings is particularly suited to EKG belt filter press treatment as they occur in large continuous volumes and are homogeneous. The dewatering of non-homogeneous materials or materials produced in low volumes or intermittently are candidates for batch treatment using EKG dewatering bags, Fourie et al. (2004), Lamont-Black et al. (2005), Jones and Lamont-Black (2006), Fourie et al. (2007), Lamont-Black et al. (2010) and Jones et al. (2011). In the case of waste sludge deposited in lagoons prefabricated (horizontal or vertical) electrokinetic drains (ePDs) can be used for *in-situ* treatment.

There are a large number of situations which give rise to the need to dewater a small or medium volume of sludge on an irregular basis. The material can be homogeneous or consist of a wide range of particle sizes. These materials can sometimes be dewatered using geosynthetic hanging bags or tubes but the technique has limitations, particularly if the waste material consists of fine particles. With fine materials problems are caused by the development of an impermeable filter cake adjacent to the drainage geotextile which causes dewatering to effectively cease after a short time. The use of EKG dewatering bag technology overcomes this problem as dewatering is related to the electrokinetic permeability rather than the hydraulic permeability of the material to be treated, Fig. 1. Lawson (2006) has identified the technical benefits of applying electrokinetic technology to dewatering of fine grained materials using EKG bags. Details of developments in EKG bag dewatering have been discussed by Hall et al. (2008).

## 3. EKG bags and dewatering procedure

Electrokinetic geosynthetics (EKG) materials are formed by the inclusion of conducting elements to geosynthetic materials using weaving, knitting, needle punching, and extrusion or laminating techniques. They can take the form of a conventional geosynthetic material and can be formed into any 2D or 3D shape. The EKG material used in the current application is a composite made up of a filter, a conducting knitted element and a woven geotextile.

**Table 2**
Types of EKG treatment and method.

| Material form | Constant supply | | Intermittent supply |
|---|---|---|---|
| | Large vol. | Small vol. | |
| Homogeneous | EKG belt | EKG belt | EKG bags |
| Mixed | Screen + EKG bags | EKG bags | EKG bags |

EKG bags have a dual function in that they not only contain the waste material but also cause the material to dewater. This is achieved by making the EKG bag into a cathode. An anode is suspended inside the EKG bag during treatment. The size and shape of an EKG bag depends on the nature and volume of the material to be treated. The EKG bag can have a "one trip" only use or be reusable. It is beneficial to arrange the geometry of the EKG dewatering bag into a bisected torus as this provides a uniform bi-directional electrical field. In addition, the bisected-torus bag doubles the flow-inducing voltage gradient and halves the flow path length, thus quadrupling the effectiveness of electro-osmotic dewatering and doubling that of hydraulic dewatering, Fig. 2. This is the form used to dewater the nuclear waste described in this paper.

EKG dewatering bags can be operated hanging from a framework or placed on the ground on a suitable draining surface. Filling the EKG bag is simple if the waste is in the form of a liquid, Fig. 3. Following an initial filling dewatering is started by the application of a low DC voltage (30–60 V). As dewatering proceeds the volume of material in the bag is reduced, Fig. 4. Once the material has reached a proscribed increase in dry solids content, and is no longer classified as a liquid, additional sludge is added to refill the bag whilst dewatering continues. This procedure is repeated until the bag is full of solidified waste. EKG dewatering bags can be used with or without flocculent and or coagulants. Use of these chemical additives may enhance dewatering and reduce the time required to turn slurry into a solid. The bags will operate on slurry of 1–10% dry solids and raise the solids content gradually over the dewatering period (typically 1–5 days). The solids content and mechanical characteristics of the dewatered sludge depends greatly on the nature of the solids. Organic sewage sludge may be improved to around 15–35%dry solids whereas the dry solids of dominantly mineral sludge may be raised to between 30 and 50+%.

The technical benefits of EKG bag dewatering have been demonstrated in trials using sludge produced as a waste from water clarification processes. Dewatering took place over four days. The results of the trials are shown in Table 3. The electro-osmotic dewatering yielded a volume reduction compared to conventional filtration dewatering of 55–75%. The conventional (non-EKG)

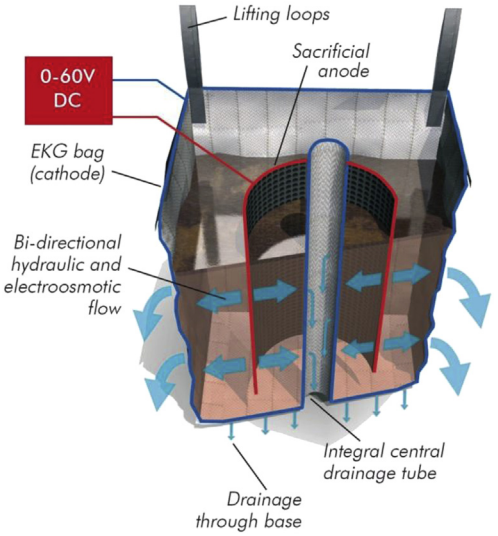


**Fig. 2.** EKG dewatering bag.