

LEACHING CHARACTERISTICS OF COMMUNAL AND INDUSTRIAL SLUDGES

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Introduction

In view of regulatory requirements and difficulties in judging treatment options for communal and industrial sludges, leaching properties of treated sludges are becoming increasingly important [1]. The leaching behaviour of sludges is largely dictated by the nature of the sludge. The main factor in this respect is the level of organic degradable matter, which may lead to the generation of Dissolved Organic Carbon (DOC) capable of metal complexation [2,3,4]. In addition, sludges may exhibit reducing properties, either by addition of sulphides as in the case of stabilization of industrial sludges or as a result of anaerobic degradation. The consequences of differences in chemical conditions on the release from sludge can be observed from pH controlled leaching experiments performed in a pH-static test. Examples are provided for a range of sludges; sewage sludge, gas production sludge, dredging sludge and galvano-sludge. Sewage sludge and gas production sludge can be classified as sludges containing organic matter whilst galvano-sludge has a typically inorganic signature. The aim of this presentation is to demonstrate similarities in leaching behaviour from different types of sludge. Similar leaching behaviour is demonstrated for the major elements: Al, Fe, Mg, Mn, S, P and the minor elements: Zn, Pb, Cu, Ba, Cr and Mo.

Materials and Methods

pH-static test

In the pH-static leach test, the pH is continuously adjusted by acid (1 M HNO₃) or base (1 M NaOH) addition to selected preset values. The general characteristics describing the tested sludges are given in table 1. The extraction is continued for 24 hours [2]. After finishing the pH-static leach test the leachate samples are filtered over a 0.20 µm filter. The leachate samples are analysed for components using ICP-AES. The results from the pH-static experiment are given for the major compounds: Al, Fe, Mg, Mn, S, P and the minor elements: Zn, Pb, Cu, Ba, Cr and Mo.

Communal sewage sludge

The communal sewage sludge used in this evaluation is obtained from the communal wastewater treatment plant located in the vicinity of ECN, The Netherlands. The communal sewage sludge was leached as received (L/S = 37.5 l/kg) at 4 pH's (4.1, 6.6, 9.4, 12.0).

Communal sewage sludge with addition of Ca(OH)₂

The sewage sludge is identical to previously described sludge. Before the pH-static leach test at a preset pH value was carried out sufficient Ca(OH)₂ was added to reach the preset pH value. Fine tuning of the pH is achieved by adjustment via addition of acid (1 M HNO₃) or base liquid (1 M NaOH). The aim of this procedure is to assess the behaviour of the sludge after lime addition. The leaching experiment were carried out on the sludge as received at 4 pH's (7.1, 9.0, 9.9, 11.9).

Gas production sludge

The production sludge used in this evaluation is obtained from a gas production facility located in the North of the Netherlands. The pH-stat experiment were performed at 4 pH's (7.6, 8.9, 9.9, 11.9) on the sludge as received with a L/S-ratio of 4.2 l/kg.

Dredge sludge

The dredge sludges is obtained from a harbor sanitation project in the South-Western part of the Netherlands. The pH-stat experiment was performed at 4 pH's (4.0, 5.5, 7.0, 8.5) on the sludge as received.

Galvano-sludge

The used galvano-sludge is obtained from a galvanic industry located in the South of the Netherlands. The sludge was diluted before the pH-stat experiment was started. The L/S ratio as received was l/kg. During the leaching experiments a L/S = 32.6 l/kg was used. The leaching was performed at 8 different pH's (4.1, 5.6, 6.6, 7.6, 8.5, 9.5, 10.5, 12.0).

Both communal sludges and dredging sludge are reducing. The general characteristics of the sludges used in this evaluation are given in table 1.

Table 1. General characteristics of the sludges under investigation.

Property		communal sewage sludge	galvano-sludge	gas production sludge	dredge sludge
Dry weight	[g/kg]	2.4	32.7	69.3	
L/S	[l/kg]	37.5 [#]	32.6 [*] (2.0 [#])	4.2 [*] (0.5 [#])	≈2.5 [#]
pH as received	[-log H ⁺]	6.5	7.3	7.5	7.6
E _H as received	[mV]	-66	276	29	-202

* The L/S-ratio applied during leaching test. [#] L/S-ratio of the material as received

Results and Discussion

The aim is to point out similarities in leaching behaviour of different sludge types demonstrated for some selected elements. The general leaching behaviour will be briefly discussed per element. When exceptional leaching behaviour is observed this will be discussed.

Aluminium. Figure a. The general leaching characteristic is determined by amorphous or crystalline (gibbsite) Al(OH)₃ and can be observed in most materials.

Iron. Figure b. In the pH domain < 7 Fe shows behaviour as Fe(III). Comparance of the Fe leaching from sewage sludge and sewage sludge with Ca(OH)₂ addition shows that Ca precipitates DOC, thereby reducing the DOC mobilisation from sewage sludge.

Magnesium. Figure c. In the high pH-region leaching of Mg is usually controlled by (brucite) Mg(OH)₂. The relatively high leaching of Mg at pH > 10 can be explained by DOC complexation.

Manganese. Figure d. Mn shows typical V-shaped leaching behaviour. Comparance of the sewage sludge and the sewage sludge with Ca(OH)₂ addition again shows the effect of DOC immobilisation.

Copper. Figure g. The solubility of Copper in inorganic systems, such as galvano-sludge, is likely to be controlled by (tenorite) CuO. The sludges with high organic matter content also leach Dissolved Organic Carbon (DOC) capable of forming organocopper complexes which are very soluble. The presence of these compounds can explain the strongly enhanced leaching of Copper for these sludges against the leaching behaviour of galvano-sludge representing a inorganic situation.

Lead. Figure f. Leaching of Pb from communal sewage sludge is controlled by Dissolved Organic Carbon which forms complexes with enhanced leachability. Leaching from gas production sludge also shows DOC controlled leaching. Leaching of the communal sewage sludge with the use of $\text{Ca}(\text{OH})_2$ shows a decrease in Pb leaching. Addition of $\text{Ca}(\text{OH})_2$ precipitates the DOC thereby reducing the DOC effect.

Zinc. Figure e. The behaviour of Zn is identical to the leaching behaviour of Pb. The effect of the DOC immobilisation using $\text{Ca}(\text{OH})_2$ shows the same results as is demonstrated with Pb and Fe.

Barium. Figure h. Leaching from communal sewage sludge and gas production sludge, at high pH, is likely to be controlled by BaSO_4 . Communal sewage sludge with the use of $\text{Ca}(\text{OH})_2$ shows that in the high pH-region leaching of the sludge is controlled by both BaSO_4 and BaCO_3 .

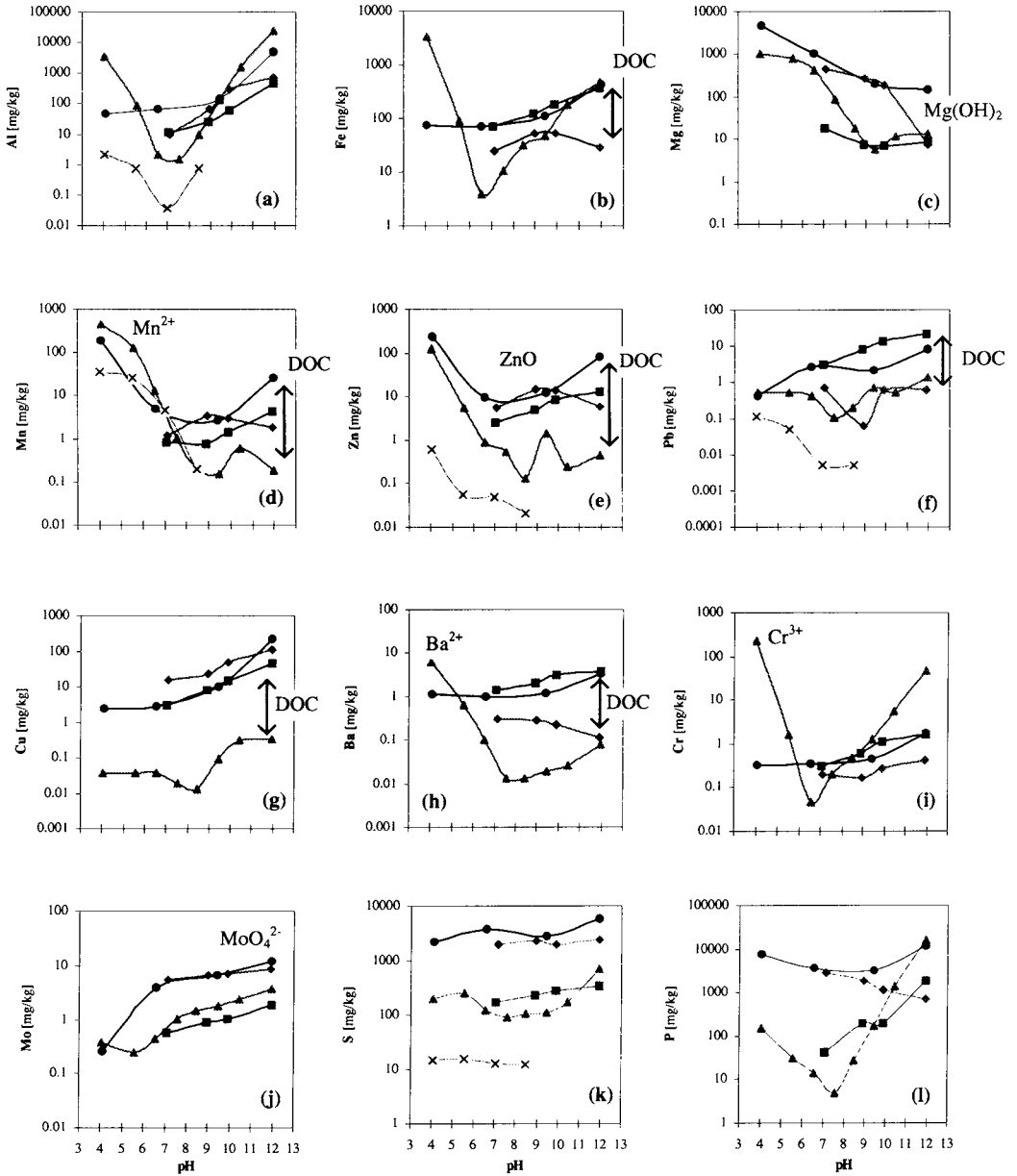
Chromium. Figure i. There are distinct differences in leaching behaviour of the galvano sludge and the sludges containing organic matter. The behaviour of these is typical for chromate leaching. Galvano-sludge demonstrates a V-shaped pattern with minimum leaching between pH 6-7. The pattern by which Cr is leaching is matching with the leaching behaviour of Fe. It is suggested that Fe controls Cr leaching. In this case Cr can be present as Cr (III).

Molybdenum. Figure j. Molybdenum exhibits typical oxyanion leaching behaviour. Above pH 5 the mobile species MoO_4^{2-} is formed.

Sulphur. Figure k. The leaching pattern of Sulphur is equal for all the sludges but differs in magnitude. The communal sewage sludge shows a high leachable amount of sulphur due to anaerobic degradation by which the sulphur is generated.

Phosphorous. Figure l. Leaching behaviour of P from the galvano-sludge is correlated with that of Fe (possibly as phosphates). High amounts of P are leached from sewage sludges because the material contains a large amount of P due to the mainly organic composition of the material. After addition of lime to the sewage sludge the amount of leachable P decreases with increasing pH.

Figure 1. Leaching characteristics of the different sludges. spheres (black): communal sewage sludge, diamonds (green): communal sewage sludge with Ca(OH)₂, squares (blue): gas production sludge, triangles (red): galvano-sludge, cross (purple): dredge sludge.



Conclusion

There is a distinction in leaching behaviour between inorganic and organic matter containing sludges. The main effect that can be noticed is the contribution of DOC to metal mobilisation and leaching. DOC mobilisation in sludges, especially in sludges with high organic matter content like communal sewage sludge, is a main controlling factor responsible for high leachability in the pH domain 7 -12. By studying the general leaching characteristics of sludges and materials the behaviour of these type of materials can be identified and management options chosen according to optimal conditions [1,5].

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