Leaching test of coal fly ash for the landfill

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Abstract

Diagenesis is a geological term which means compaction, cementation and replacement of sedimentary rock occurring under normal temperature and pressure of the outer earth’s crust. Similar phenomena will occur at the landfill of coal fly ash. From this view point, a simple column method is tested. Fly ash is set in the bottom of a plastic pipe, and water penetrates by gravity from the water head pressure.

In the last study, we reported that self-cementation of a fly ash decreased a dissolution of harmful element. In this paper, it is reported a different fly ash which did not decay the water flux with time and continued to effluent boron. By both results, the new method will not only anticipate the state of drainage from fly ash landfill, but also have a provision against the harmful components in the future.

1. Introduction

Coal fly ash is utilized for the materials of cement production, concrete mixture, artificial light weight aggregate, artificial zeolite, agricultural composite etc. So far as the case of utilization, producers have always to care the pollution. Unfortunately, we cannot find any information to predict the quantity, dimension, order of magnitude of harmful elements from fly ash landfill.

Lin et al.[1, 2, 3] already reported that not only the dissolution but the deposition occurs by conventional leaching tests. We cannot estimate the real migration amount of the aimed element by conventional test.

We proposed a new method[4] to solve the faults of conventional method. The hint of this method is primarily suggested by geological evidence. Mineral crystallization sometimes occurs in pore sedimentary grains. Moreover, volcanic glass is apt to be mineralized in short term, as far as the geologic time. We call this phenomena "diagenesis" [5]. The diagenesis make the sediment harden and impermeable. Fig.1 shows an example of diagenesis.

Ground water not only dissolves the elements of rocks but also precipitates the saturated components. Similar phenomena will occur in the landfill fly ash.

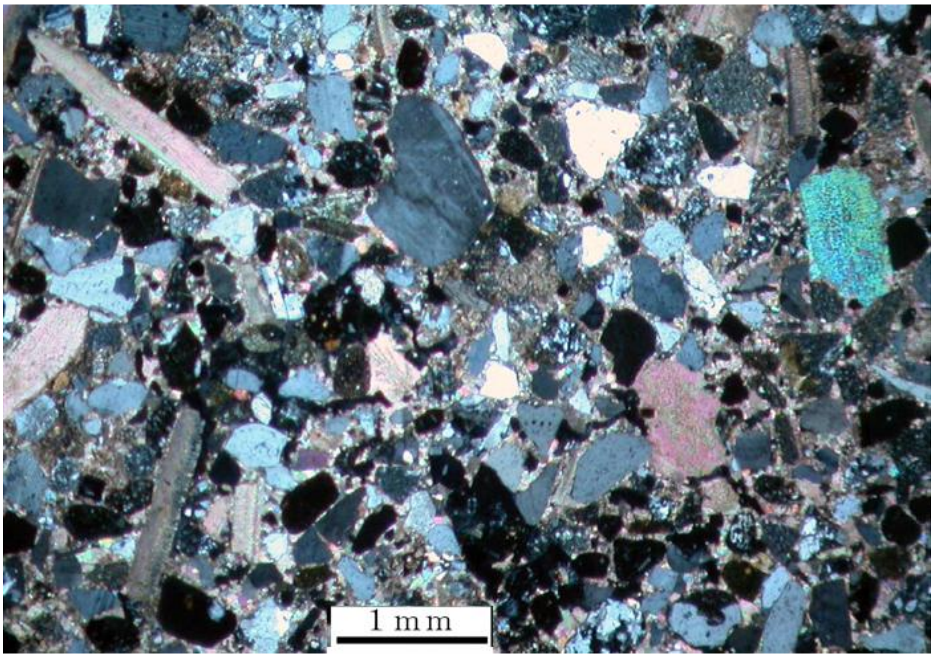

Fig.1 Microscopic photo of a diagenesis. Sand deposited in Tokyo bay about 100000 years ago. This sand is commonly loose except a locality of diagenesis. In this photo, gray to white minerals is quartz or feldspar which is original minerals. The coloured and irregular shape is fragment of shell fossil which is the original, too. And fine grained and coloured mineral is calcite (calcium carbonate) which is secondarily precipitated in pore.

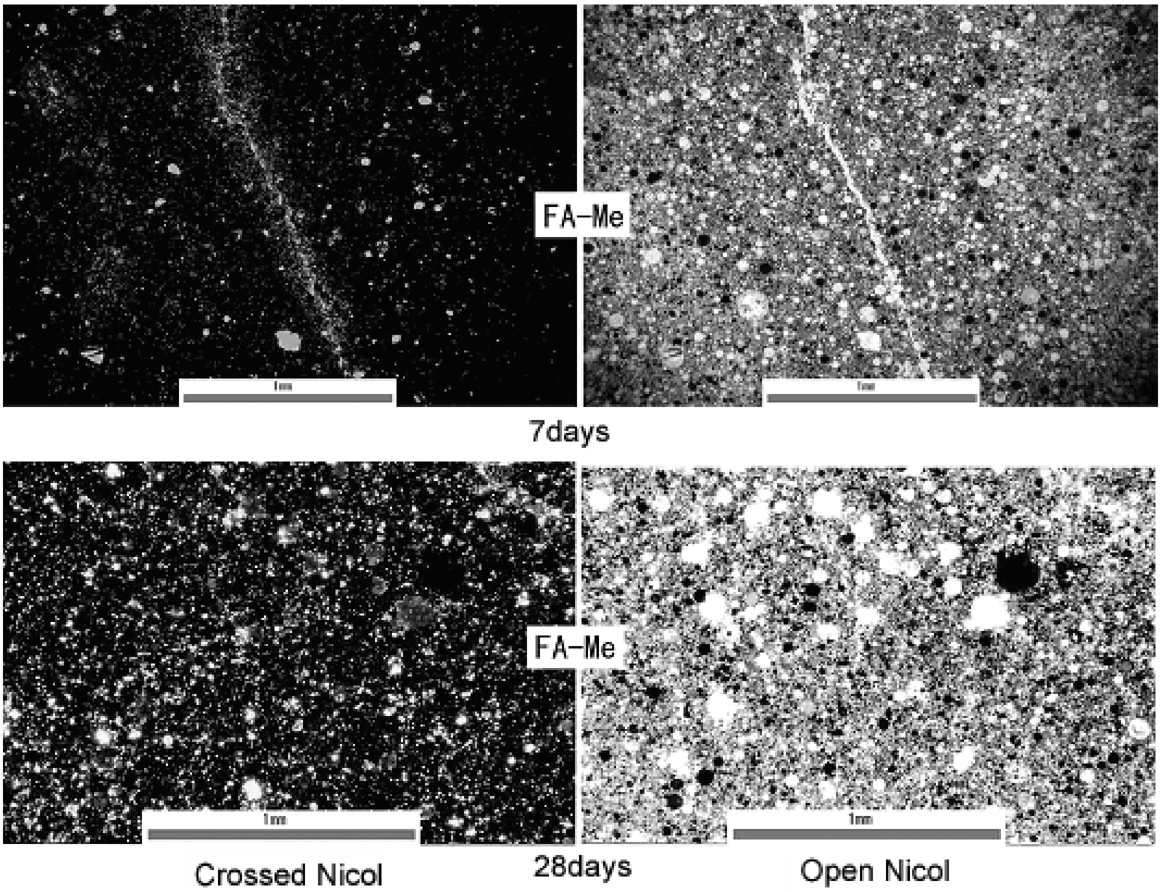

Fig.2 Optical microscope[4]. Compare the crossed Nicol of 7 days and 28 days. A lot of mineral (bright particles) crystallized in three weeks.

We concluded[4] dissolution and precipitation occur in the column. Precipitation of carbonate mineral or other mineral decreases the porosity of the column, and decreases the concentration of metallic ions in the drainage. This will decrease the pollution. It has been impossible to predict these phenomena by the conventional method. In this paper, different fly ashes reported before are tested to develop the possibility of the new method.

2. Experiments

2.1 A tested column

A column was designed by an assumption that rain water is the main resource of penetrating through the fly ash landfill. As shown in Fig.3, fly ash is set in the bottom of a plastic pipe and water penetrates by gravity and the pressure of 150mm or 225mm head water. Diameter of the pipe was 28mm or 56mm. The percolated water is collected to measure the volume at arbitrary interval which depends on the rate of water flux. Then concentrations of aimed elements were analyzed by ICP and other methods.

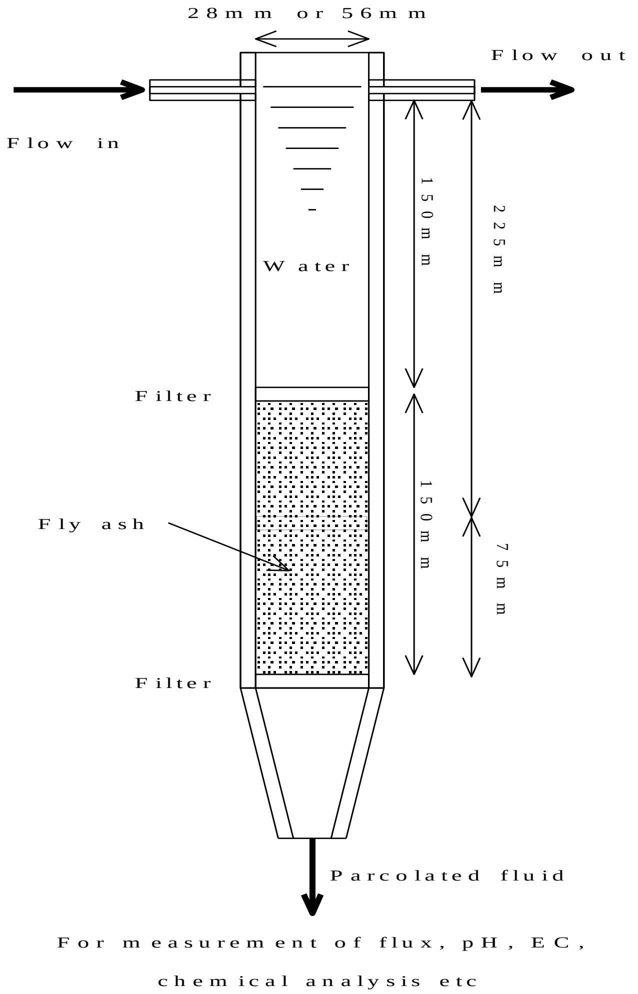

Fig.3 Schematic cross section of a tested column

After the run, the column pipe was dried in a vacuum dry oven at 80 degree centigrade to prevent carbonation of metallic ions by carbon dioxide in the air. A plastic fluid was penetrated into the dried fly ash in a vacuum condition. Then after, the sample was heated in atmosphere at 80 degree centigrade about two to four days to consolidate the plastics. The sample was cut to observe the inside of fly ash body. Fig.4 shows an example of cut one. Then, thin sections were made from hardened body. Observation of the thin sections was carried out by a polarized microscope. The other side was used for x-ray microanalysis.

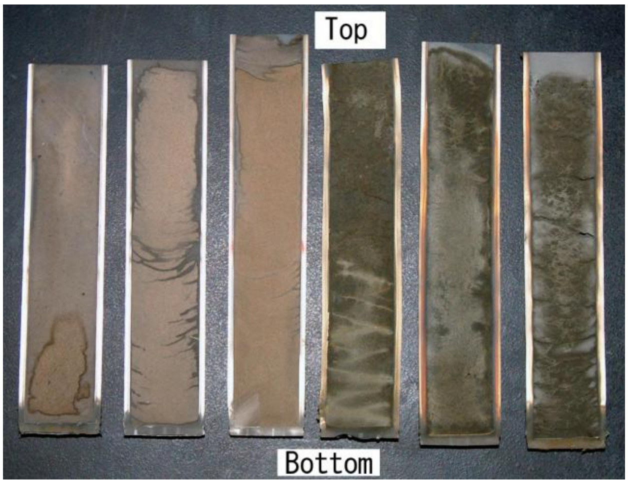

Fig.4 An example of cut column[4]

2.2 Tested Fly Ash

Unfortunately, we already consumed the sample used in the last study. In this study, three original fly ashes were tested. The two fly ashes were from two electric power plants in Japan, and the other from an electric power plan in Thai. These samples were named as Tkh, Nae and Tm3 respectively. Chemical compositions of the fly ash are listed in Table 1, and elements concentrations of the leachates by Japanese Test of Leaching (JTL) No.46 are listed in Table2. Tm3 contains high CaO, and is the most soluble than the others by leaching tests. As far as the results of leaching test, boron in Nae is the most unsafe of the three. On the other hand, total solubility of components in Tm3 is observable, but boron is lowest of the three.

Table1 Chemical components of fly ash used (mass %)

	Ig.Loss	SiO_2	Al_2O_3	Fe_2O_3	Na_2O	K_2O	MgO	CaO	B*	Cr*	SO_3	Soluble by HCL
Tkh	1.6	54.6	36.7	3.5	0.3	0.5	0.8	1.4	62	120	0.1	6.0
Nae	2.7	57.2	26.8	5.2	1.1	1.4	2.3	3.0	160	100	0.5	7.5
Tm3	2.9	40.8	22.6	13.9	1.1	2.5	2.8	13.2	210	62	1.3	74.0

＊ppm

Table 2 Concentration of elements in leachate by JTL 46 test
(L/S=10, shake 6 hours in pure water)

	Ca	Na	Al	Si	B	Cr	SO_4
Thk	506	92	16	9	10.2	0.2	1467
Nae	1084	197	56	23	44.6	1.1	2414
Tm3	7601	799	8	12	4.3	0.9	10020

3. Experimental results and Discussion

3.1 Flow rate

Accumulative flow related to curing time is shown in Fig.5. In this figure, Tkh, d=56mm, h=150mm, is sample name, inner diameter of the pipe, thickness of fly ash bed respectively. As seen in these figures, three of two of Tm3 almost stopped percolation around 700 hours (about one month). The fastest run was about 150 hours at the last study[4]. This difference may be caused by difference of fly ash origin and diameter of column pipe. At the run (Tm3, d=28mm, h=150mm), a crack which opened from top to bottom appeared next day of the start. Because water might flow through this crack, the flow rate never changed as shown in Fig.5. This crack would be occurred by shrinkage of the fly ash bed. Therefore we have to find the best conditions for setting of ash.

3.2 pH and EC

Results of pH and electric conductivity (EC) were shown in Fig. 6. The pH change with time has a tendency which converges to medium pH, except at the run (Tm3, d=28mm, h=150mm) which continued high pH as far as 100 hours.

Initial conductivities of Tm3 were high, but attenuation rate was very big. In the run (Tm3, d=28mm, h=150mm), decrease rate of EC suddenly changed at 10 hours from beginning. This change would be influenced by the generation of a crack. Since the dissolved ions would accumulate to the crack, the ion concentration did not decrease so rapidly.

If the (Tm3, d=56mm, h=150mm) and (Tm3, d=56mm, h=75mm) is compared, there is no clear difference at water flux, dissolution degree of elements, etc. As far as the experiments, it was impossible to find the effect of the dimension. It is needed to continue the experiment related to scale of equipment.

3.3 Dissolved elements in the percolated water

Fig.7 and 8 shows the results of chemical analysis. Dissolution rate of components generally decreases in a short period, especially Na and B decrease rapidly. This suggests that dissolution primarily occurs from some Na/ B bearing salts deposited on the particle surface. The Na salt may be mainly sulfate, judging from the chemical analysis. After the dissolution from the salt, dissolution will mainly be from cenophere and minerals. Because the dissolution rates from minerals are commonly negligible small, dissolution from the cenosphere would be dominant. Even though the dissolution of main elements decreased, Si and Al continued to be solved. This means that dissolution of Si and Al are supplied from the cenosphere.

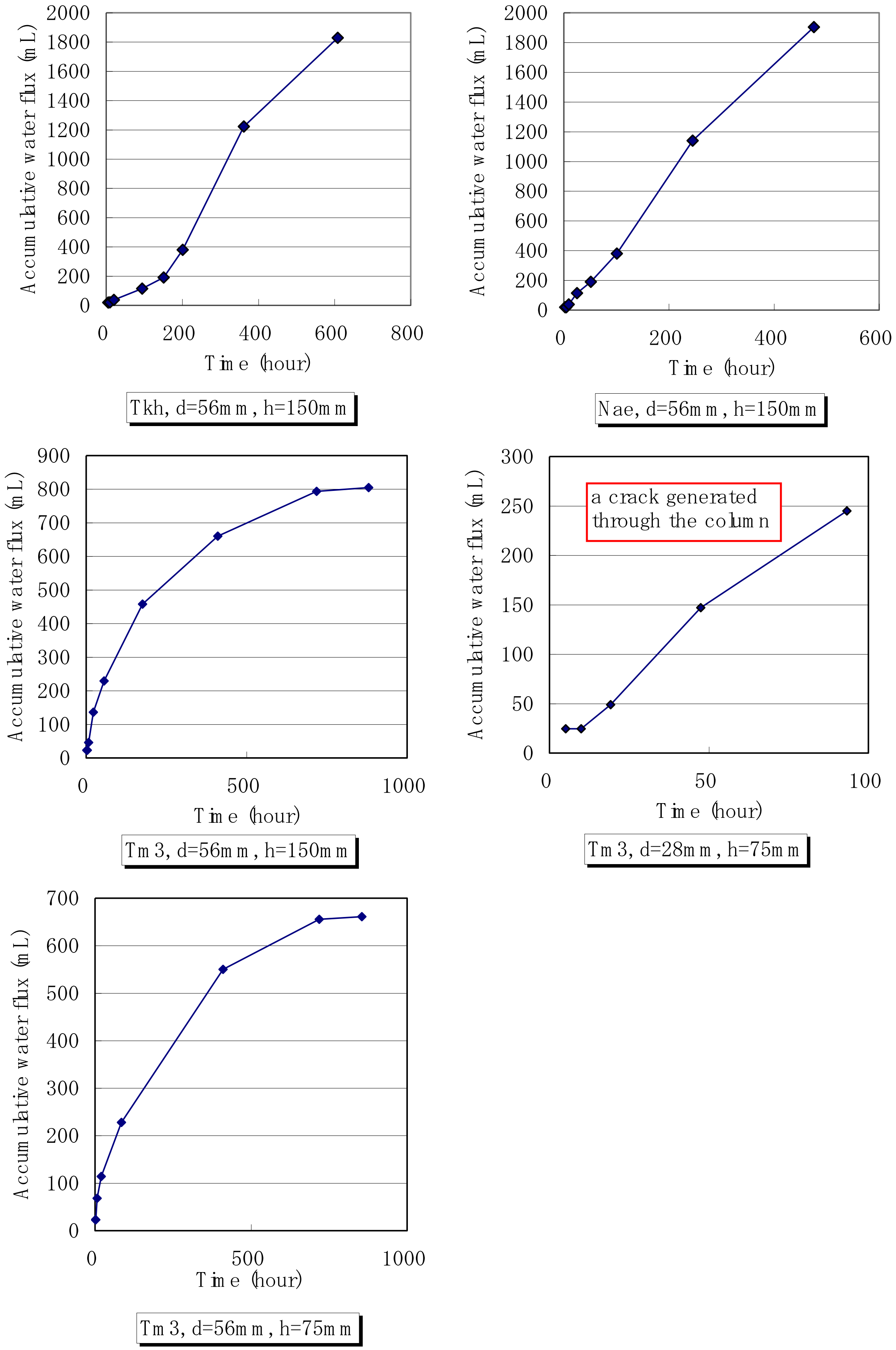

Fig.5 Relation between percolation time and accumulative water flux.

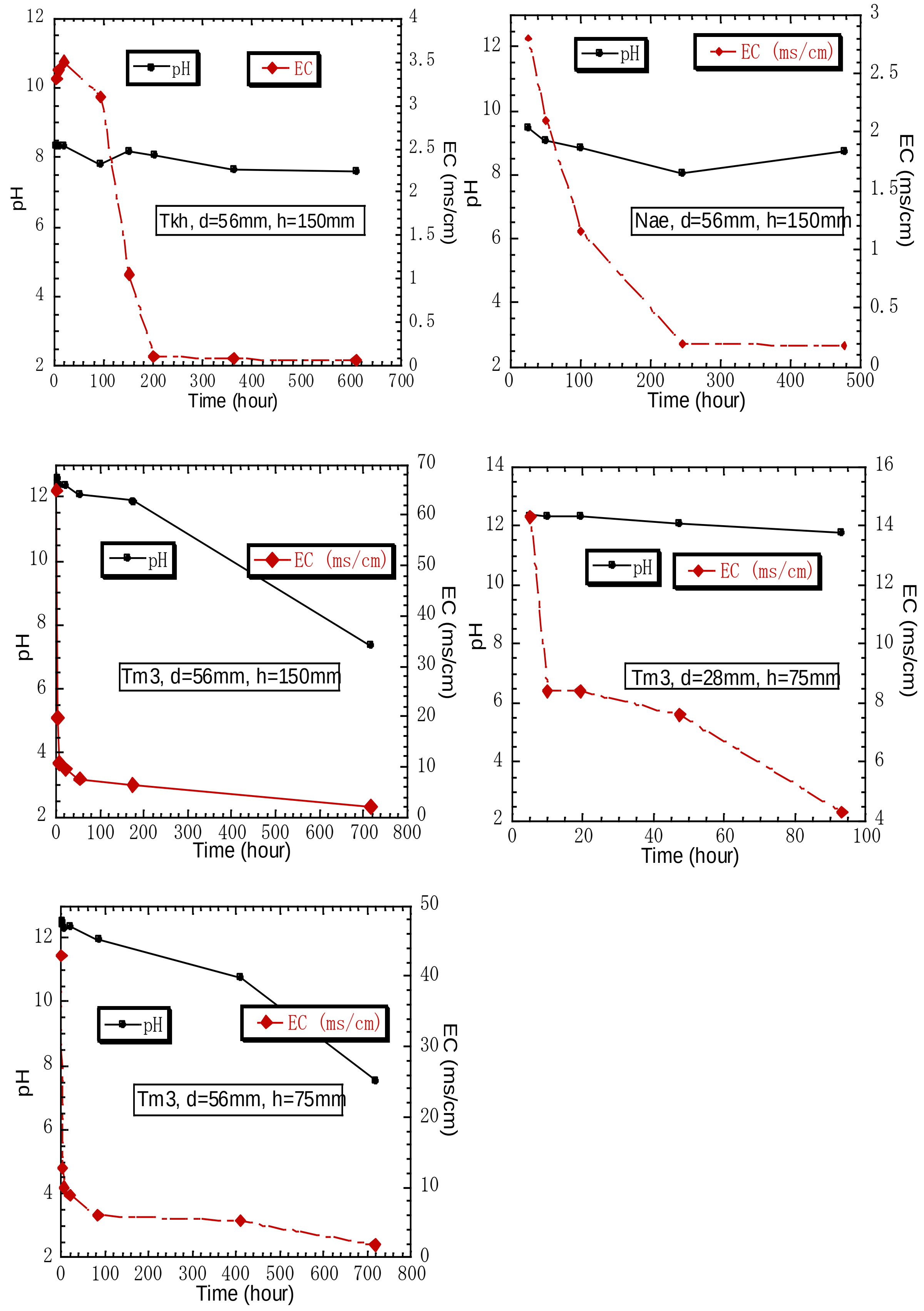

Fig.6 Relation between percolation time and pH/EC

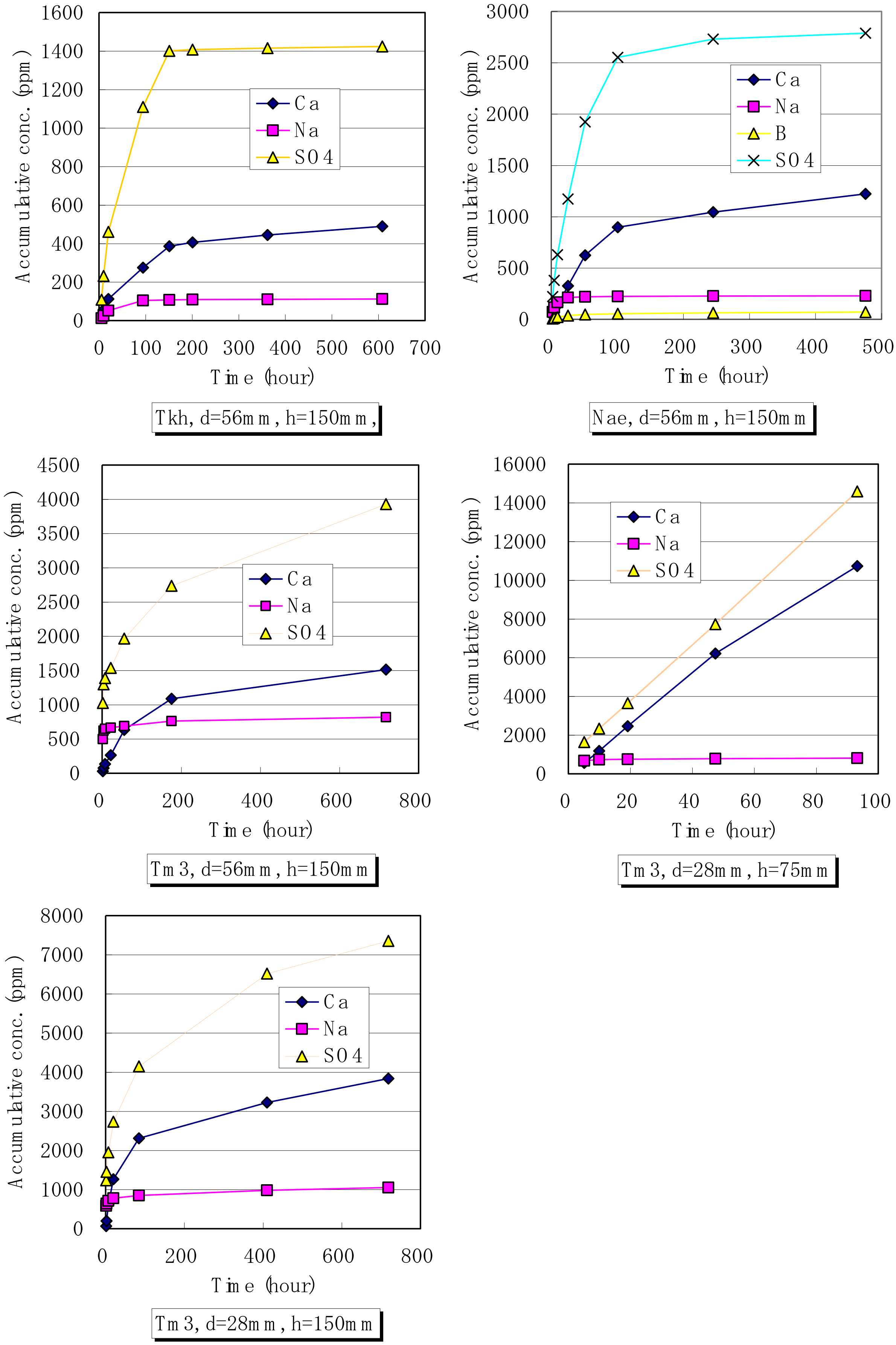

Fig.7 Relation between percolation time and accumulation of dissolved elements (1)

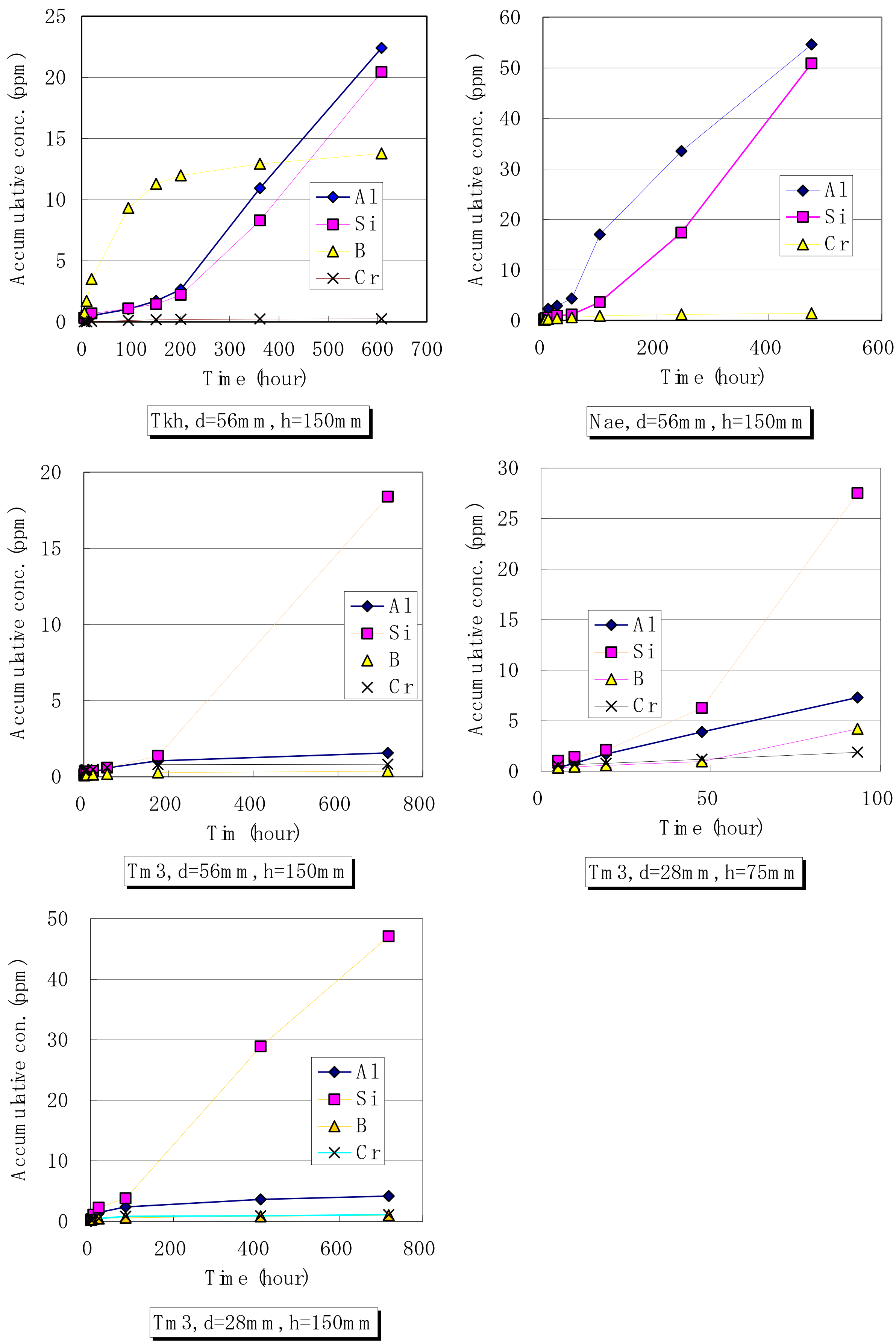

Fig.8 Relation between percolation time and accumulation of dissolved elements

Tm3 is the most soluble in the three fly ashes from Fig.7 and Table2, and these columns stopped the percolations. The same tendency was found in the last study[4]. This means that some components reach to saturation during time when water passed through the fly ash bed.

When the concentration ratio of Tms and Thk of JTL46 (Table2) and ratio of Tms and Thk of column tests (Fig.5) is compared, the latter is smaller than former. This would be caused by precipitation of some elements in the column.

Table3 shows the accumulative concentrations of elements by column test when the liquid/solid ratio reached to around 10, and results by JTL46 (test of L/S=10) is juxtaposed. In the cases of (Tm3, 28mm, 150mm) run and (Tm3, 56mm, 150mm), L/S did not arrive to ten, because the flow stopped by cementation. It is mow impossible to explain the reason, but both values are very similar. It will be necessary to check this tendency to other fly ash.

Table3 Analytical results of column test when the percolated water retained to L/S=10 and results by JTL No.46 test (6 hours shaking in pure water, L/S=10)

Sample name (way of analysis)	Dimension of fly ash bed	Time (hour)	Ca	Na	Al	Si	B	Cr	SO_4
Tkh (Column)	56mmX150mm	608.25	489	112	20.6	20.4	13.8	0.26	1424
Tkh (JTL46)		6.00	506	92	16.4	9.3	10.2	0.25	1467
Nae (Column)	56mmX150mm	475.75	1222	227	54.6	50.9	70.8	1.43	2787
Nae (JTL46)		6.00	1084	197	55.9	22.7	44.6	1.15	2414
Tm3 (Column)	28mmX75mm	93.25	10732	814	7.3	27.5	4.2	1.87	14589
Tm3 (JTL46)		6.00	7601	799	7.8	12.5	4.3	0.93	10020
Tm3 (Column)	28mmX150mm	not achieve							
Tm3 (Column)	56mmX150mm								

4. Conclusion

Though this investigation started two years ago, it is in the preliminary step. There are many problems to be solved. But it is able to conclude, as follows,

1. High soluble fly ash precipitates some component, because saturation arrives in short time. In this case, pores in fly ash bed are filled by the crystal, and fly ash bed becomes impermeable. These phenomena will occur at fly ash landfill.
2. If undesired element is highly contained in the high soluble fly ash, the element will be fixed in the crystal or leached out hardly from impermeable body. This would be same at the landfill.
3. On the other hand, if undesired element is highly contained in low soluble fly ash, the element will dissolve out in drainage for long period. When these fly ashes are

found, it is able to provide an appropriate fend.

4. Results by the new method will not only anticipate the state of drainage from landfill, but also will give a provision against the harmful components in the future.

Acknowledgement

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References

[1] J. M. Lin, T. Saeki, T. Nagaoka, and T.Tanosaki. Characterization of Fly Ashes by leaching Test, World of Coal Ash (2005) Kentucky

[2].T. Tanosaki, G. Bröns-Laot, J. Méhu, M. Abdelghafour, Astrid Genet, P. Moszkowicz Compotement Environnemental du Chrome et du Bore de la Valorisation de Cendres Volantes de Charbon, (2006) Dechets (French in press)

[3] D. Guyonnet, F. Bodenan, G. Bröns-Laot, M. Crest, L. Chateau, J. Méhu, P. Moszkowicz, and P. Piantone. Pollutant emission from waste: influence of scale and rate of percolation, (2005) WasteEng2005 Albi

[4] M. Nambu, T. Tanosaki, Z. M. Lin, T. Saeki, P. Moszkowicz, O. Peyronnard, and J. Mehu, New characterization method of fly ashes, Proceeding of 6th ISCC CANMET/ACI Symposium, Xian(2006)

[5] S.Boggs, Principles of Sedimentology and Stratigraphy 2nd ed. (1995). Prentice Hall.