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EDITORIAL

Is an ultra long-life final disposal site sustainable?

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The World Heritage Committee of UNESCO decided to inscribe Mount Fuji on the U.N. agency's prestigious World Heritage list in June 2013. This happy news is expected to bring more tourists. A solid action not to compromise sustainability of Mt. Fuji is imperative because garbage discarded by tourists becomes problematic. By the way, for a tourist place associated with garbage, I recommend the Futatsuzuka final disposal site for municipal solid waste (Fig. 1) in the Tama region with land area of 59.1 ha, and landfill capacity for waste of 2.5 million m^3. This landfill site receives garbage from 4 million residents at Tama region, west of Tokyo. It is the quietest and the most beautiful landfill site which I have ever visited domestically and internationally. It does not emit any specific garbage odor. Residual volume of the landfill site is 1.3 million m^3. Given the fact that the amount of landfill disposal of noncombustible garbage in a few years will reach 3,000 m^3/year, the lifetime of the landfill site is estimated to be more than 400 years, which is, I believe, long lasting for a landfill. Even in the case of noncombustible garbage after separation, conveyed to the site once or twice a day by a truck, no scavenger crow visits the site. On the contrary, in residential areas, in the university where I am working, and in public parks in cities, hundreds of annoying crows scavenge in the garbage. What a big difference! I have been engaged in preserving the environment after construction of this landfill site and in maintaining it for 20 years. I will relate the background history below to make us believe that the Futatsuzuka landfill site is the cleanest and long lasting.

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Tokyo with 23 wards and the Tama region enjoy different methods for treating municipal solid wastes. In 23 wards with 8 million residents, municipal solid wastes are incinerated, turned into bottom and fly ashes. These ashes have been reclaimed at the sea area landfill site, which is located in seaside of Tokyo Bay and owned by Tokyo Metropolitan Government. Since 1990, the ashes have been turned into molten slag as a recycle roadbed material, to prolong the lifetime of the landfill site. This is a sound practice of a material-cycle society. However, the elution of heavy metals such as lead from the roadbed material has been problematic. Given this reason, exploitation of roadbed materials has not been successful. Eventually, molten slag is disposed of at the sea area landfill site.

The Tama region, on the other hand, consisting of 25 cities and 1 town where 4 million people are living, collects and transports combustible wastes. They are incinerated, and the incineration ashes are disposed of at the Futatsuzuka landfill in an mountainous area in the Tama region. In contrast, noncombustible wastes are collected, transported, crushed, and separated in a sequential order. Some parts are recycled; however, the rest is disposed of at the Futatsuzuka landfill. This system was implemented in 1997 and, if this continues as expected, then the landfill would reach its volume capacity in 2013. The Tama region consequently was forced to select a new landfill site for construction to avoid such a situation. However, the construction was already determined to be impossible according to the environment assessment. The main reason for the infeasibility stemmed from deep-rooted objection from the local people. Hinode municipality, west of the Tama region, has a landfill site with the capacity full of garbage, called the Yatozawa landfill site, operation of which was finished in 1996. In this site, the containment designed to bottle up contamination was ruptured, and the

Fig. 1 Futatsuzuka final disposal site and eco-cement facility in Hinode-town (provided by the Tokyo Tama Regional Office)

potential elution of leachate was designated. Certainly chloride ion and electrical conductivity in groundwater collection drainage under the bottom synthetic membrane liner of landfill site began to increase in 1992. As soon as the sign of leakage was observed, the following countermeasures were carried out. Hundreds of monitoring wells around the landfill site were constructed and monitoring activities were intensified. After recovery and treatment of all groundwater collection drainage was performed, and all effluent was discharged into the sewerage pipe. We have checked such monitoring data and confirmed that the increase of chloride ion concentration around the landfill site, particularly in downstream groundwater of the landfill site, has not been observed. Given this context, the citizens were strongly against development of a new landfill site, i.e., Futatsuzuka landfill site, because they thought environmental pollution from the landfill site would diffuse out. They filed several lawsuits, which included substitute execution by administration and construction injunction on the disposal site. Given these histories, the landfill sites located at the Tama regions were justifiably charged with the mission to prolong their lifetimes, which are a much higher priority, than those alongside the Tokyo Bay in 23 wards.

To deal with the situation, an eco-cement facility was proposed in 1997. Detailed analyses including technical administrative procedures were conducted and, finally, the eco-cement facility with treatment/processing capacity for incinerated ashes of 330 ton/day and cement production capacity of 520 ton/day was completed in the confine of the Futatsuzuka landfill site in 2006. The term "eco-cement," representing hybrid words of ecology and cement, is a new type of cement produced by bottom and fly ashes, as the main constituents, from the incineration plants. Exploitation of these wastes is in harmony with the environments. This cement contains chlorine lower than 0.1 % in weight.

Conveyed incinerated ashes are dried and mixed with other materials by crushing, followed by baking in a cement kiln at more than 1,350 °C, producing clinker. Plaster is added to the clinker, resulting in shipment of eco-cement after crashing. In the cement kiln, lead, zinc, copper, and metals are reacted with chlorine due to chloride volatilization. Finally, ash dusts as a final material are captured by a bug filter. As a result, although ash dust contains high-strength heavy metals, clinker does not contain any toxic heavy metals and chlorine except chrome. Hence, the ash dusts are treated by water, acid, and alkaline extraction, separating dehydrated sludge containing lead and copper, and solution containing sodium chloride. The former is purchased by private metal-finishing plants. The solution with salinity at the same level as seawater is confirmed to make sure that heavy metal concentrations, lead, cadmium, and mercury meet the effluent

standards. The solution is subsequently discharged to a sewerage. By the way, mass balance of radioactive cesium in the eco-cement facility has been investigated several times. The radioactive cesium transported from incinerated residues was not detected in the eco-cement, exhausted gases, or dewatered sludge, but present in solution extracted from heavy metals and discharged to sewerage. Since the eco-cement facility has been under operation since 2006, all incinerated residues are recycled as eco-cement. In 2012, the amounts of the residues and of the produced eco-cement were 78,700 and 115,800 ton/year, respectively. The price of the eco-cement was set at the same price as for normal cement.

Given only the history, Futatsuzuka seems an ideal sustainable landfill site. However, we should not condone extremely high capital costs, i.e., 500 million US$ for construction of the final disposable site; 272 million US$ for construction of the eco-cement facility, as well as high operational costs, e.g., 200 US$/t for disposal of incinerated residues and noncombustible garbage; and 500 US$/ton for eco-cement production. The Tama region in the Metropolis of Tokyo installed the eco-cement facility to achieve a sustainable final landfill site in place of investment of such enormous amount.