Utilization of geothermal drill cutting into bricks and concrete roads for reducing drilling waste

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Abstract. In the process of geothermal power plants, it is necessary to drill wells to take hot steam from inside the earth to rotate the power plant turbines. In its operation, these steam wells need to be maintained through workover activities. From drilling and workover activities resulting in drill cutting which becomes a problem because it cannot be disposed into the environment. In one drilling campaign program, 200-300 tons of drill cutting were produced which could not be disposed into the environment. For this reason, the best way to manage drill cutting waste is to use it for its own needs, so that the volume of waste is reduced. Based on the results of the study, the appropriate use of drill cutting is to use it as raw material for making bricks and concrete roads, because the processing is low cost, absorbs quite a lot of local manpower and the results can be used for internal purposes such as buildings, roads, drainage, and other infrastructure projects, so that economic, social and environmental benefits can be obtained at the same time. The drill cutting processing method is very simple starting with the drying process by drying it to reduce the water content, then drill cutting that has been dried mixed with cement in a certain formula, then printed into bricks and concrete roads which are then dried for the hardening process. Based on the use of drill cutting in the Gunung Salak geothermal power plant, this drill cutting utilization method has succeeded in reducing drill cutting to 100% so that it is not a problem for the environment. During the running time monitoring is done by monitoring wells, especially along concrete roads and the results show good parameters. From the results of the strength test, the brick and concrete roads produced from drill cutting have a strength that meets Indonesia National Standards (SNI).

Keywords: Drill cutting, geothermal, waste

1. Introduction
Population and economic growth make a demand for electricity supply continue to increase. This is what makes the development of renewable energy power plants considered a national need that can no longer be delayed. Electrical energy has now become a major need in people's lives, the need for...
electricity in Indonesia which continues to increase rapidly along with the increase in development, economic growth and also the increase in the population in Indonesia.

One potential source of electrical energy comes from geothermal energy, where Indonesia has enormous potential sources. According to data from the Geological Agency, Ministry of Energy and Mineral Resources, until the end of 2016 there were at least 331 geothermal energy source locations throughout Indonesia, where most of the potential was on volcanic lines with a potential of 28,579 MWe with details of 11,073 MWe and estimated reserves around 17,506 MWe and installed capacity of 1,534 MWe. The utilization of geothermal energy is currently used entirely for electricity generation (table 1).

| Island(s)          | Resource Speculative (MWe) | Hypothetical (MWe) | Expected (MWe) | Possible (MWe) | Proven (MWe) | Installed (MWe) |
|--------------------|---------------------------|--------------------|----------------|----------------|--------------|-----------------|
| Sumatera           | 2,883                     | 1,935              | 5,097          | 930            | 917          | 177             |
| Jawa               | 1,410                     | 1,689              | 3,949          | 1,373          | 1,865        | 1,224           |
| Bali-Nusa Tenggara | 295                       | 431                | 970            | 110            | 45           | 12,5            |
| Kalimantan         | 152                       | 17                 | 13             | -              | -            | -               |
| Sulawesi           | 1,221                     | 314                | 1,242          | 80             | 140          | 120             |
| Maluku             | 560                       | 91                 | 775            | -              | -            | -               |
| Papua              | 75                        | -                  | -              | -              | -            | -               |
| Total location     | 6,596                     | 4,477              | 12,046         | 2,493          | 2,967,0      | 1,533,5         |

Geothermal power plants are known as environmentally friendly power plants (figure 1). Like photovoltaic and wind, power generation from geothermal power produces air pollution which is little compared to using fuel oil. Land use for geothermal power plants is smaller per megawatt than other types of power plants. Otherwise, in the process of geothermal power plants, it is necessary to drill wells to take hot steam from inside the earth to rotate the power plant turbines. In its operation, geothermal energy is taken from the earth by making production wells. The type of steam produced from production wells can be wet steam, called brine water, such as the Gunung Salak power plant or dry steam such as in the Gunung Darajat and Kamojang power plant, West Java. These steam wells need to be maintained through workover activities. From drilling and workover activities resulting in drill cutting which becomes a problem because it cannot be disposed into the environment. In one drilling campaign program, 200-300 tons of drill cutting were produced which could not be disposed into the environment.

The use of drill cutting is one of the efforts for environmental management carried out by the Gunung Salak power plant as a form of corporate responsibility in carrying out sustainable development in the environmental aspects. According to Minister of Energy and Mineral Resources Regulation No. 21 of 2017 concerning the management of drilling mud and drill cutting in Geothermal states that business entities carrying out geothermal drilling must carry out management of drilling mud waste and drill cuttings to prevent, mitigate and or restore the possibility of pollution and or environmental damage. Ex-situ utilization and in situ utilization are used for construction materials such as road base, concrete road coating materials, construction of soil and concrete retaining walls, raw materials or mixtures of concrete block materials and other uses as construction materials.

The objective of this research is how to reduce drill cutting waste by utilizing it as useful material, so this research is project-based, where the results of research in the laboratory are directly applied in the field.
2. Methodology

2.1. Toxicity test of drill cutting

The toxicity test is to test material characteristics. This test is carried out using the Toxicity Characteristic Leaching Procedure (TCLP) method for solid waste, as stipulated in Government Regulation No. 85 of 1999 concerning B3 waste management. This characteristic test uses solid material in the form of drill cutting and further analysis using the Atomic Absorption Spectrophotometry (AAS) instrument in the laboratory. This test was carried out with the consideration that drill cutting is a natural material carried from inside the earth from a depth of 9,000 feet, has the potential to carry heavy metal content.

2.2. Concrete composition

To get good quality concrete from drill cutting, a trial is needed to get the right mixture of material. The pattern approach for the activity using drill cutting as a pavement coating material in principle is to approach technically, economically and environmentally. By understanding this pattern, it can be predicted whether the effort is feasible to be developed either commercially or only used for internal purposes.

Tests carried out include drill cutting testing in the laboratory to determine the composition of the drill cutting to make the right composition of the concrete and press cylinder testing of several concrete compositions that have been dried up to the age of 28 days.

2.3 Drill cutting utilization at the field

After obtaining the concrete composition, the field was applied for the use of drill cuttings for road pavement and brick making with the step as follow:

1. Storage and drying
2. Preparation for road pavement or bricks production.
3. Environment monitoring
3. Result and Discussion
To ensure the safety of the use of drill mud and drill cuttings, a Toxicity Characteristic Leaching Procedure (TCLP) test was conducted. The results of laboratory tests show that the content of hazardous materials in drill cutting is far below the threshold listed in Annex II Government Regulation No. 85 of 1999 concerning Management of Hazardous and Toxic Waste so that in principle drill cutting is safe for humans (table 2). In 2017, drill cutting from geothermal drilling activities is no longer classified as hazardous and toxic waste by the Ministry of Energy and Mineral Resources.

| Test Description | Result (mg/L) | Regulatory limit (mg/L) |
|------------------|---------------|------------------------|
| Arsenic          | < 0.002       | 5.0                    |
| Barium           | 1.027         | 100.0                  |
| Boron            | 1.214         | 500.0                  |
| Cadmium          | < 0.004       | 1.0                    |
| Chromium         | < 0.007       | 5.0                    |
| Copper           | < 0.006       | 10.0                   |
| Lead             | < 0.04        | 5.0                    |
| Mercury          | < 0.0002      | 0.2                    |
| Selenium         | < 0.002       | 1.0                    |
| Silver           | < 0.007       | 5.0                    |
| Zinc             | < 0.002       | 50.0                   |

The composition for road construction is divided into 2 ways are:

1. The first layer uses drill cutting as the base-road layer of the composition of the first layer: 1 m$^3$ of drill cutting, 0.18 litters of soil stabilizer, 3 sacks of cement, 2 sacks of lime. This composition also used for brick production.
2. The second layer is the concrete surface layer using a mix-design composition of concrete road composition: 0.69 m$^3$ drill cutting, 0.54 m$^3$ aggregate (with a mixture of 50% aggregate size 1-2 cm, 50% size 2-3 cm), 0.18 litters soil stabilizer, 10 sacks of cement.

For road construction, the following steps are carried out:

3.1. Storage and drying.
Drilling mud and cutting from drilling activities are accommodated in the containment sump to be dried by evaporation. Drill mud and cutting can only be used to mix road pavement and brick production if the water content has completely dried. Dry drill cutting is then moved and stored in a temporary storage shelter (figure 2 and 3).

![Figure 2. Transfer drill mud to the containment sump](image1)

![Figure 3. Dry drill cutting storage area](image2)
3.2 Preparation for road pavement
Preparation for road pavement begins with making the first layer as a base road. After the base layer has dried, then proceed with mounting the framework as a mold for the second layer hardening (figure 4 and 5).

![Figure 4. Installation of framework](image1)

![Figure 5. Second layer pavement](image2)

3.3 Environment monitoring
To ensure that there is no pollution to water and soil, monitoring wells are made on the side of the front and the end of the road to do water sampling and analysis in the laboratory every 6 months (figure 6). From the results of laboratory analysis, all parameters including total organic matter, pH, specific conductivity, manganese, iron, free ammonia, chloride is still within the range of local baseline monitoring results before construction of the concrete road. It is important to know whether there have been environmental changes caused by the construction of concrete roads and the results have not changed.

![Figure 6. well monitor the environment](image3)

3.4 Brick production
Another way to process drill cutting is brick production that is quite involving local employees involved in the production (figure 7). It takes 2 until 3 people to work on making solid bricks. In addition to having a positive impact on the economic development of the local community, the results obtained from the production of solid brick can be utilized to the maximum extent possible for internal needs in the construction of the company’s infrastructure.
4. Conclusion
Drilling activities in geothermal power plants, produce waste in the form of drill cutting and drilling mud that need to be managed so it will not an impact on the environment. The most potential utilization is by making drill cutting and drilling mud as a concrete mixture for road pavement and bricks.

From the results of the trial and implementation at the Gunung Salak geothermal power plant, it shows the utilization of 100% drill cutting and drilling mud as a mixture of concrete roads and bricks so that no waste is produced.

Environmental monitoring is conducted in the monitoring wells and there is no evidence of environmental change on water and soil around the concrete road.

Making concrete bricks provides economic and social benefits to the community around drilling activities because the process carried out is still labor-intensive so it requires a considerable amount of labor to produce bricks. In 1 production line, it takes 2 until 3 workers to make bricks from stirring to printing.

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