BIOEDUSCIENCE
ISSN: 2614-1558
http://journal.uhamka.ac.id/index.php/bioeduscience

The Effect of Coal Bottom Ash and Compost Soil Media on the Growth of Red Chili Plants (*Capsicum annuum*)

Nunung Eni Elawati [1*], Carmelia Santania Fahik [1], Arifah Nurul Izza [1], Fika Ainur Rahmawati [1]

[1] Biomedical Science study Program, Ivet University, Jl. Pawiyatan Luhur IV No.16, Bendan Duwur, Kec. Gajahmungkur Semarang, Indonesia, 50235
* Correspondence: nunungenie@gmail.com

Abstract

Background: Coal burning activities at PLTU leave large amounts of waste every year, which can become a problem of environmental pollution. Bottom ash is known to contain nutrients needed by plants. This study aims to determine the effect of adding a mixture of compost to ameliorate bottom ash on the pH and plant growth of *Capsicum annuum*. **Methods:** The study used a completely randomized design (CRD) with three replications and four formulations, namely B0 = coal waste (200g); B1 = 100g of bottom ash: 100g of planting medium; B2 = 50g bottom ash: 150g planting medium, and B3 = 150g bottom ash: 50 g planting medium. Parameters observed included plant height, number of leaves, root length, number of roots, total Biomass, and pH. **Results:** The results showed that treatment B0 had the highest pH and B2 had the lowest pH. Treatment B2 successively showed the most heightened plant height, the largest total Biomass, and the most increased root length and had a significant effect on leaf number but had no significant effect on root number. **Conclusions:** The application of bottom ash with soil compost media impacted the pH and the growth of C. annuum plants, especially in plant height, number of leaves, total Biomass, and root length of C. annuum plants.

Keywords: Bottom Ash; *Capsicum annum*; Coal; Plant Growth.

Article history
Received: 22 Feb 2023
Accepted: 29 Apr 2023
Published: 30 Apr 2023

Publisher's Note:
BIOEDUSCIENCE stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Citation: Elawati, N.E, Fahik, C.S., Izza, A.N., & Rahmawati F.A. 2023. The Effect of Coal Bottom Ash and Compost Soil Media on the Growth of Red Chili Plants (*Capsicum annuum*). *BIOEDUSCIENCE, 7*(1), 1-7. doi: 10.22236/jbes/7111185

Introduction

Coal-burning activities at PLTU leave large amounts of waste every year. Coal combustion produces around 5% of solid pollutants in fly ash and bottom ash (Damayanti, 2018), of which around 10-20% is bottom ash and about 80-90% of fly ash of the total ash produced (Noviardi, 2013). Increasing the supply of electrical energy by constructing new power plants correlates with an increase in coal waste produced. If coal waste is not used optimally, it will become a problem of environmental pollution (Utami, 2018).

Chemically, coal ash is an aluminosilicate mineral that contains many elements such as Ca, K, and Na while also containing small amounts of parts C and N (Hermawan, Sabaruddin, Marsi, Haryati, et al., 2014). Other nutrients in coal ash that are needed in the soil for plants include Boron (B), phosphorus (P), and elements such as Cu, Zn, Mn, Mo, and Se (Dwivedi & Jain, 2014). Generally, coal ash is alkaline (pH 8-12). Physically, it has a silt-sized particle size and has moderate to high water-binding capacity characteristics (Yuyun, 2015).

So far, research on coal waste has been used for agriculture and construction (Prasetia et al., 2014). Several studies have focused a lot on the use of fly ash in agriculture, such as research by Utami (2018), which states that using fly ash as a mixture of organic fertilizers can increase the pH of the fertilizer, namely with a pH of 8.52. However, fly ash does not affect the amount of N content, P, and K. Bottom ash is still limited to its use as a building construction material (Ria Nur et al., 2020).

Fly ash is more often used than bottom ash as a soil conditioner in recent research on coal ash because fly ash has a smaller size, namely 0.001 – 100 m, compared to bottom ash

(0.1–10 mm) (Agustini & Wahdaniyah, 2017). According to Noviardi (2013), Besides containing toxic materials, bottom ash also contains nutrients plants need. The chemical composition of bottom ash is mainly composed of the elements Si, Al, Fe, and Ca, as well as Mg, S, Na, and other chemical aspects. The silicate and alumina content contained in bottom ash is active because it can react with other components. Silica in bottom ash plays a role in helping the dissolution of element P in planting media containing the nutrient phosphate (Kinasti et al., 2018).

The soil's acidity can be corrected by liming, but acid soils require large amounts of liming and are given continuously, so it is expensive (Ilham et al., 2021). Using coal bottom ash as a substitute for lime is considered more efficient because it utilizes unused waste. Previous research conducted by Kinasti et al. (2018) used bottom ash from PLTU Suralaya as a hydroponic medium for Kangkung (*Ipomea autica*), kale (*Brassica rapa* var.) and lettuce (*Lactuca sativa)*. However, this research is still not optimal due to excess nutrients in the nutrient water. So, it is necessary to find alternatives for utilizing bottom ash as a planting medium with other additions such as compost soil. Based on this, seeing the potential of bottom ash which can be utilized as organic fertilizer, it is necessary to research to determine the effect of bottom ash and compost soil media as an ameliorant material on pH and growth of red chili *Capsicum annuum*.

Method

Place and time of research

This research was conducted at the Common Use Laboratory Gardens, Universitas Ivet, Semarang, Central Java, from November 2022 to January 2023.

Materials

The tools used in this study included polybags measuring 25 x 25 cm, shovels, rulers, stationery, a soil pH meter, and digital scales. The materials used include red chili seeds (*C. annuum*) obtained from the farm store "Infarm.id", bottom ash waste obtained from PLTU Tanjung Jati B Jepara, soil media ready for planting from the farm shop, and gloves.

Procedure

This experiment used a completely randomized design (CRD) with three replications consisting of 4 treatment formulations, namely: B0= bottom ash (200g); B1= formulation ratio 1:1 (100 g bottom ash: 100 g soil media); B2= formulation ratio 1:3 (50 g bottom ash: 150 g soil media), and B3= 3:1 formulation ratio (150 g bottom ash: 50 g soil media).

Observational variable

Data collection was carried out by measuring several parameters on red chili (C. annuum) plants, including plant height (cm), number of leaves (strands), number of roots (pcs), root length (cm), total Biomass (g), and pH. All parts of the chili plant obtained Total Biomass were dried in an oven at 70°C for 1 hour, and pH was measured using a soil pH meter.

Data analysis

Data analysis used the SPSS 21 program. Observe data was tested with ANOVA at a rate of 5%, then Duncan's further test was carried out with a 5% confidence level to determine the differences between treatments in each treatment.

Result and Discussion

Chemical characteristics of ameliorants from bottom ash formulations and compost soil media

The chemical characteristics of amelioran formulation of basic ash and compost soil media are presented in Figure 1.

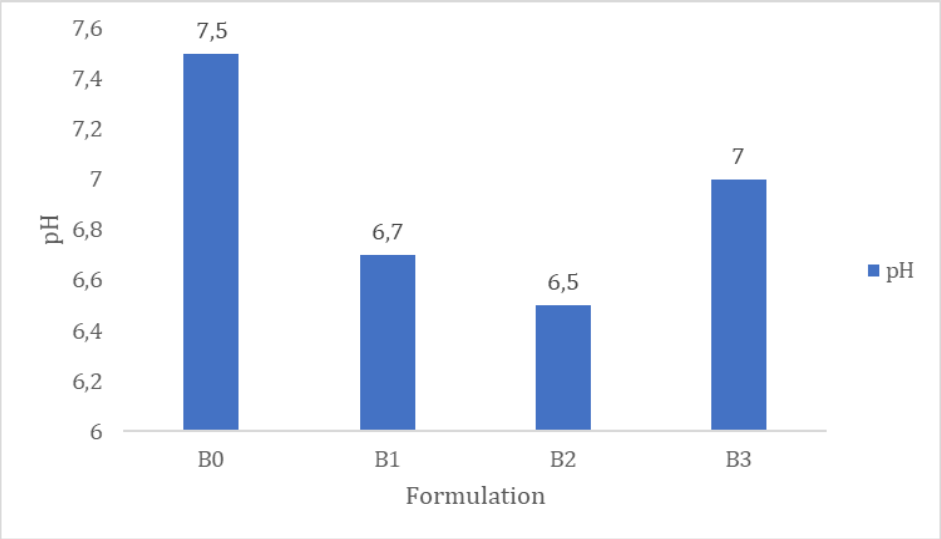

Figure 1. The pH Characteristics of The Bottom Ash Formulation and Compost Soil Media

The highest pH content in the coal waste was 7.5 in the formulation (B0), namely 200g bottom ash coal waste, and the lowest pH in the B2 formulation, namely 1:3 bottom ash waste and compost soil media. The addition of coal ash increases the negative charge of the soil through the deprotonation mechanism of H+ ions in clay minerals (Priatmadi et al., 2014). Hermawan, Sabaruddin, Marsi, Hayati, et al. (2014) state that coal flying waste can be used as a neutralizing agent for soil pH and can potentially reduce the use of lime to reduce soil acidity, due to the mineralogical characteristics of coal waste complex.

According to Noviardi (2013), coal waste has an alkaline pH, macro and micronutrients, and sufficient size. Causes coal waste to increase nutrient content and improve the structure and moisture capacity. Based on statistical tests with a significance level of 5%, the analysis of pH measurements on the experimental formulations was significantly different, with a p-value <0.05, meaning that the experimental formulations affected pH. However, Duncan's test for the four formulations showed no significant difference.

pH conditions determine the success of *C. annuum* growth. If the soil is too acidic, it can cause phosphate (P) deficiency. The availability of P decreases below pH 5.5 because it is fixed by Al, Fe, hydroxide, and clay, while above pH 7.0, P is fixed by Ca and Mg (Jamilah & Dwiputranto, 2016). According to Pokovai et al. (2020), the appropriate pH for chili plants ranges from 5.5 to 6.8, with an optimum pH of 6.0 to 6.5. Bottom ash can increase the soil pH value, positively correlated with plants, such as plant growth or weight (Musfira et al., 2021). The results showed that formulation B2 was the best for *C. annuum* plant growth.

According to Agustini & Wahdaniyah (2017), coal bottom ash has the potential to be used as an ameliorant that will not damage soil, plants, or the environment with organic matter that can increase cation exchange capacity (CEC), increase nutrient availability, affect pH and energy sources for microorganisms in the soil. This study is similar to that of Mashfufah & Prasetya (2019), stated that treatment of the ground with the addition of compost from a mixture of citronella leaf pulp and 15% fly ash (w/w) resulted in the pH of the planting medium being stable in neutral conditions (Khasanah & Budiono, 2022).

Effect of Formulation on Plant Height

The results showed that the ameliorant bottom ash formulation with compost soil media affected the increasing height of *C. annuum* plants. A summary of statistical analysis of the effect of the application of ameliorant bottom ash formulation with compost soil media on plant height of *C. annuum* is presented in Table 1.

Table 1. Effect of Formulation on Plant Height

Treatment	Plant Height (cm)
B0	3.30 ± 0.33 a
B1	5.83 ± 0.44 b
B2	6.50 ± 0.29 b
B3	3.67 ± 0.67 a

Note: Numbers followed by the same letter in the same column are not significantly different from Duncan's test at the 5% level.

Based on observations, the height of red chili plants ranges from 3.30-6.50 cm. Physically, plant height in the B2 formulation shows the highest plant. According to Jamilah & Dwiputranto (2016), the P element found in compost soil affects the leaf surface's expansion so that the plant photosynthesis rate can increase. At the same time, the B0 formulation showed the lowest plant effect. This indicates that adding nutrients by bottom ash at this percentage has impacted the growth of *C. annuum* plants. Even though the treatment with the ameliorant formulation did not have a significant effect, it is suspected that the heavy metal content in coal can inhibit plant growth (Febriana et al., 2021).

The Effect of Formulation on The Number of Leaves

The results of the effect of basic ash and compost soil media on the number of leaves are presented in Table 2.

Table 2. The Effect of Formulation of the Number of Leaves

Treatment	Number of Leaves (Strands)
B0	2.78 ± 0.11 [a]
B1	3.00 ± 0.00 [a]
B2	3.89 ± 0.11 [c]
B3	2.89 ± 0.11 [a]

Note: Numbers followed by the same letter in the same column are not significantly different from Duncan's test at the 5% level.

Table 2. shows that increasing the dose of coal fly ash affected the decrease in the number of leaves of the chili plant. Statistical analysis showed that the effect of giving bottom ash formulation with compost soil media significantly impacted the number of leaves of *C. annuum* plants. The results of Duncan's test of the impact of the treatment of adding bottom ash and compost soil media to the number of leaves of *C. annuum* sunflower plant biomass can be seen in Table 4 and Table 5. Duncan's test showed that formulation B2, namely a ratio of 1:3, produced the most number of leaves and was significantly different from other treatments.

According to Febriati & Rahayu (2019), the nitrogen (N) content found in compost affects plant growth, including the number of leaves, because nitrogen is one of the elements forming proteins, and nucleic acids play an essential role for plants. Khofiyya et al. (2021), stated that bottom ash affects the soil's phosphorus content and the number of plant leaves. Phosphorus plays a role in nucleic acid formation, energy transfer, and stimulation of enzyme activity. This study's results differ from the research of Febriana et al. (2021) in that the concentration of coal waste has no significant effect on the number of leaves.

Effect of Formulation to Total Biomass of C. annuum

The effect of adding coal and compost waste to the average Biomass (Table 3.). Table 3. shows treatment B2 has the highest total Biomass, followed by B3. Meanwhile, treatment B0 showed the least amount of Biomass. Based on statistical tests with a significance level of 5%, the total biomass analysis of the experimental formulations was significantly different with a p-value <0.05, which means that the experimental formulations affected total Biomass. However, the B2 and B1 treatments did not show a significant difference in the Duncan test. Likewise, the B0 and B3 formulations did not show a significant difference. These results are consistent with research conducted by Febriana et al. (2021); the cause of the higher the fly ash from coal, the lower the dry weight of the plant.

Table 3. Effect of Formulation to Total Biomass of *C. annuum*

Treatment	Total Biomass (g)
B0	0.11 ± 0.03 [a]
B1	0.14 ± 0.02 [b]
B2	0.37 ± 0.12 [b]
B3	0.32 ± 0.24 [a]

Note: Numbers followed by the same letter in the same column are not significantly different from Duncan's test at the 5% level.

Coal waste contains micronutrients needed for plant growth; coal waste can improve the soil's physical properties, moisture, and air circulation (Noviardi, 2013). Furthermore, Nurindriana & Wicaksono (2022) revealed that compost could increase soil fertility, physical properties, plant growth, and Biomass.

Effect of Formulation on the Length and Number of Roots of C. annuum

The result of adding coal waste and compost to root length can be seen in Table 4.

Table 4. Effect of Formulation on Root Length

Treatment	Length root (cm)
B0	2.20 ± 0.26 [a]
B1	3.56± 0.73 [b]
B2	3.63 ± 0.21 b
B3	2.97 ± 0.28 b

Note: Numbers followed by the same letter in the same column are not significantly different from Duncan's test at the 5% level.

The results of data analysis through the application, coal feeding significantly affects the length of the roots. Therefore this suggests that an increased dose of coal dust affects plants' decreased root length. Duncan's test showed that the B0 treatment significantly differed from the other treatments. The root length of *C. annuum* plants decreased with the increase in the number of doses of coal fly ash. The heavy metal content in coal bottom ash is suspected of inhibiting root growth, so plant roots cannot absorb nutrients and grow properly. The study's results Win et al. (2020), revealed that the heavy metal Cd content caused a decrease in the germination ability of wheat plants.

On the other hand, according to a statement by Faoziah et al. (2022), humic compounds from organic matter indirectly increase soil porosity by increasing the activity of microorganisms which improves the physical condition of the soil to be able to hit the soil structure to become loose so that the physical condition of the earth becomes better for root growth.

The B2 treatment showed the highest root length results, presumably because the composition of the compost soil media was taller so that the nutrients were sufficiently available for the plants. According to Win et al. (2020), compost contains a variety of microorganisms and plant nutrients. It is known that microorganisms in the soil and rhizosphere assist in the growth of ferns and the absorption of heavy metals. Further, according to Hariadi et al. (2016), The addition of ameliorant bottom ash adds P nutrients in the form of phosphate ions, which are needed by plants for the formation of cells in the tissues in the roots and can increase the number and size and weight of seeds. The effect of adding coal waste and compost to several sources can be seen in Table 5.

The statistical analysis results showed that the results were not significantly different ($p \geq 0.05$) between the treatments given. These results indicate that the application of bottom ash does not affect the number of roots. That can happen because roots are accumulators of heavy metals found in waste. According to Nurindriana & Wicaksono (2022), plant roots can be used as a phytoremediation agent, which can absorb rich metal content from the soil to be transferred to all plant parts. Furthermore, Nirola et al. (2015). state that the bioavailability of heavy metals can affect soil properties that plant roots can absorb more. In contrast to research conducted by Febriana et al. (2021), which apPplied fly ash (fly ash) to affect the kale plant's number of roots.

Table 5. The Effect of Formulation on the Number of Roots

Treatment	Number of Roots (pcs)
B0	3.67 ± 0.33 ^{ns}
B1	5.00 ± 0.57 ^{ns}
B2	4.33 ± 0.33 ^{ns}
B3	4.67 ± 0.88 ^{ns}

Note: ns= not significant

Conclusions

Based on the study's results, the application of bottom ash with compost soil media affected the pH and growth of C. annuum plants, especially in plant height, number of leaves, total Biomass, and root length C. annuum plants. Treatment B2 was the best treatment, with the formulation of 50 grams of bottom ash and 150 grams of soil medium.

Declaration statement

The authors reported no potential conflict of interest.

References

Agustini, R. Y., & Wahdaniyah, G. (2017). Utilization of Coal Bottom Ash and Cattle Manure as Soil Ameliorant on Acid Soil and Its Effect on Heavy Metal Content in Mustard (Brassica juncea). *J Trop Soils*, *22*(2), 87–95. https://doi.org/10.5400/jts.2017.v22i2.87-95

Damayanti, R. (2018). Abu Batubara dan Pemanfaatannya: Tinjauan Teknis Karakteristik Secara Kimia dan Toksikologinya. *Jurnal Teknologi Mineral Dan Batubara*, *14*(September), 213–231. https://doi.org/10.30556/jtmb.Vol14.No3.2018.966

Dwivedi, A., & Jain, M. K. (2014). Fly Ash – Waste Management and Overview : A Review. *Recent Research in Science and Technology*, *6*(1), 30–35.

Faoziah, N., Iskandar, & Djajakirana, G. (2022). Pengaruh Penambahan Kompos Kotoran Sapi dan Fly Ash Bottom Ash (FABA) Terhadap Karakteristik Kimia pada Tanah Bertekstur Pasir dan Pertumbuhan Tomat. *Jurnal Ilmu Tanah Dan Lingkungan*, *24*(April), 1–5. https://doi.org/10.29244/jitl.23.2.78-82

Febriana, S., Priyadi, P., & Taisa, R. (2021). pengaruh Aplikasi Abu Terbang BAtubara dan pupuk Kandang Sebagai Bahan Amelioran Terhadap Pertumbuhan Tanaman Kangkung (Ipomea reptans Poir.). *Jurnal Agrotek Tropika*, *9*(1), 161. https://doi.org/10.23960/jat.v9i1.4478

Febriati, N. D., & Rahayu, Y. S. (2019). Penambahan Biochar dan Bakteri Penambat Nitrogen (Rhizobium & Azotobacter sp.) terhadap Pertumbuhan Tanaman Kedelai (Glycine max) pada Tanah Kapur. *LenteraBIo*, *3*(2012), 62–66.

Hariadi, A., Rochmiyati, S. M., & Andayani, N. (2016). Pengaruh Pupuk Hayati dan Pupuk P terhadap Pertumbuhan Mucuna bracteata. *Jurnal Agromast*, *1*(1), 1–10.

Hermawan, A., Sabaruddin, Marsi, Haryati, R., & Warsito. (2014). Perubahan Titik Muatan Nol dan Muatan Negatif Abu Terbang Batubara akibat Penambahan Kotoran Ayam dan Waktu Inkubasi. *Agroekoteknologi Tropika*, *3*(4), 191–200.

Hermawan, A., Sabaruddin, Marsi, Hayati, R., & Warsito. (2014). Perubahan Jerapan P pada Ultisol Akibat Pemberian Campuran Abu Terbang Batubara-Kotoran Ayam. *Sains Tanah – Jurnal Ilmu Tanah Dan Agroklimatologi*, *11*(1), 1–10.

Ilham, F., Maulana, A., Hasiholan, B., & Ilham, I. (2021). Pengaruh Aplikasi Amelioran dari Formulasi Limbah Batubara (Fly Ash dan Bottom Ash) dan Sampah Pasar dengan Kapur terhadap pH, KTK dan P Tersedia Ultisol dan Gambut. *Jurnal Tanah Dan Sumberdaya Lahan*, *8*(1), 239–247. https://doi.org/10.21776/ub.jtsl.2021.008.1.27

Jamilah, M., & Dwiputranto, U. (2016). Pertumbuhan Cabai Merah (Capsicum annuum L.) pada Tanah Masam yang Diinokulasi Mikoriza Vesikula Arbuskula (MVA) Campuran dan Pupuk Fosfat. *Biosfera*, *33*(1), 37–45. https://doi.org/10.20884/1.mib.2016.33.1.347

Khasanah, L., & Budiono, A. (2022). Pengaruh Penambahan FABA Terhadap Sifat Fisik dan Derajat Keasaman (pH) Kompos. *Distilat*, *8*(3), 460–468.

Khofiyya, N., Sondari, N., & Parlinah, L. (2021). Pengaruh Perbandingan Komposisi Media Tanah Pasca Tambang dengan pembenah Tanah Faba terhadap Kemasaman tanah dan Pertumbuhan Land Cover Crop (Pueraria javanicum). *PASPALUM : Jurnal Ilmiah Pertanian*, *9*(1), 43–52. https://doi.org/10.35138/paspalum.v9i1.274

Kinasti, R. M. A., Lestari, E., & Mayasari, D. (2018). Potensi Pemanfaatan Limbah Pembakaran Batubara (Bottom. *Jurnal Kilat*, *7*(1), 36–46.

Mashfufah, L. F., & Prasetya, B. (2019). Pengaruh Abu Terbang Batubara, Kompos Tandan Kosong Kelapa Sawit, dan Mikoriza Terhadap Ketersediaan Dan Serapan Fosfor, Pertumbuhan Dan Produksi Jagung Pada Ultisol. *Jurnal Tanah Dan Sumberdaya Lahan*, *6*(2), 1261–1272. https://doi.org/10.21776/ub.jtsl.2019.006.2.7

Musfira, Jayadi, M., & Ahmad, A. (2021). Application of Humic Substances and Bottom Ash Compounds in Improving Soil Quality in Limestone Post-Mining Land. *IOP Conf. Series: Earth and Environmental Science*, *807*, 1–9. https://doi.org/10.1088/1755-

1315/807/2/022038

Nirola, R., Megharaj, M., & Palanisami, T. (2015). ScienceDirect Evaluation of Metal Uptake Factors Of Native Trees Colonizing An Abandoned Copper Mine E A Quest For Phytostabilization. *Journal of Sustainable Mining*, *14*(3), 115–123. https://doi.org/10.1016/j.jsm.2015.11.001

Noviardi, R. (2013). Limbah Batubara Sebagai Pembenah Tanah dan Sumber Nutrisi: Studi Kasus Tanaman Bunga Matahari (Helianthus Annuus). *Jurnal RISET Geologi Dan Pertambangan*, *23*(1), 67. https://doi.org/10.14203/risetgeotam2013.v23.70

Nurindriana, F. M., & Wicaksono, K. S. (2022). Tanaman Sawi Utilization of Biochar and Black Soldier Fly Compost in Phytoremediation of Lead Contaminated Soil and Their Effect on Growth and Yield of Mustard. *Jurnal Tanah Dan Sumberdaya Lahan*, *9*(2), 297–309. https://doi.org/10.21776/ub.jtsl.2022.009.2.10

Pokovai, K., Toth, E., & Horel, A. (2020). applied sciences Growth and Photosynthetic Response of Capsicum annuum L . in Biochar Amended Soil. *Applied Sciences*, *10*(4111), 2–15. https://doi.org/10.3390/app10124111

Prasetia, I., Ma'ruf, & Riswan. (2014). Potensi Pemanfaatan Limbah Abu Batubara Sebagai Bahan Konstruksi di daerah Rawa. *Jurnal Teknologi Berkelanjutan (Sustainable Technology Journal)*, *5*(2), 71–78.

Priatmadi, B. J., Akhmad Rizalli, S., & Meldia, S. (2014). Pengaruh abu batubara terhadap perbaikan sifat kimia tanah di kalimantan selatan. *Buana Sains*, *14*(2), 1–6.

Ria Nur, H., Prihantono, & Anisah. (2020). Pemanfaatan Abu dasar (Bottom ash) dan Kapur Sebagai Pengganti Sebagian Semen pada Paving Block sesuai dengan SNI 03-0691-1996. *Menara: Jurnal Teknik Sipil*, *15*(1), 14–22. https://doi.org/10.21009/jmenara.v15i1.18126

Utami, S. W. (2018). Karakteristik Kimiawi Fly Ash Batu Bara dan Potensi Pemanfaatannya Sebagai Bahan Pupuk Organik. *Agrointek*, *12*(2), 108–112. https://doi.org/10.21107/agrointek.v12i2.4048

Win, Z. C., Diaz, L. J. L., Perez, T. R., & Nakasaki, K. (2020). Phytoremediation of Heavy metal Contaminated Wastes from Small-scale Gold Mining Using Pityrogramma calomelanos. *E3S Web of Conferences*, *7*(148), 1–10. https://doi.org/10.1051/e3sconf/202014805007

Yuyun, M. (2015). Analisis Dampak Industri Stockpile Batu bara Terhadap Lingkungan dan Tingkat Kesehatan Masyarakat Desa Pessir Rawa Urip Kec. Pangenan Kab. Cirebon. *SCIENTIAE EDUCATIA*, *5*(2), 1–11. https://doi.org/10.24235/sc.educatia.v4i2.490