Assessment of Reduction of Inorganic and Nutrient Contamination Levels for Water Quality Improvement using Granulated Coal Ash

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Introduction

Granulated Coal Ash, or GCA, is a by-product of coal thermal electric power plants. GCA is composed of 85% granulated coal ash and 15% cement which serves as a binder. Its chemical composition is mainly composed of Silicon Oxide (SiO_2), Aluminum Oxide (Al_2O_3), Calcium Oxide (CaO), and Carbon Oxide. Developed in Japan, it has been reported that GCA has adsorbing properties. For this study, GCA will be applied in a Philippine setting. As water quality in the Philippines differ from that of Japan, this study aims to examine the efficiency of GCA in improving water quality in Estero de San Miguel. Wastewater collected from Estero de San Miguel was poured into containers filled with different volumes of GCA. Samples were taken from each container at different retention times (7, 14, and 21 days), and measured for water quality parameters (e.g., pH, redox potential, inorganic content).

Material and Methods

Varying volume of GCA were added to 1 liter of wastewater collected from Estero de San Miguel and put in container jars. The wastewater is dewatered and replenished every cycle which lasted for 7 days. GCA was not replaced during replenishing of wastewater. This was done for 3 cycles. Parameters were measured at the start (on day 1) and end (on day 7) of each cycle.

Dissolved oxygen was measured by direct measurement using portable handheld meter. Chemetrics Inc. Vacu-Vials Test Kits and V2000 Chemetrics photometer were used to measure Phosphate and Ammonia. Phosphate was measured by Stannoud Chloride Method, while Ammonia was measured by Direct Nesslerization.

Results and Conclusions

a) Phosphate

Decrease in phosphate was observed after 7 days of contact with GCA as shown in Figure 1. This decrease can be can be attributed to the adsorption capacity and dissolution of calcium ions in GCA (Asaoka & Yamamoto, 2010). The alkaline surface of the GCA attracts phosphate ions present in the wastewater. The dissolution of calcium ions from calcium hydroxide also bonds with phosphate ions to form a calcium phosphate.

Average reduction rate per phase is shown in Table 1. As each phase is replenished with new wastewater, results of Day 1-7, Day 8-14, and Day 16-22 are presented separately. Reduction rate for the first phase (day 1-7) is recorded to be 66%, 53% for the second phase (day 8-14), and

57% on the third phase (day 16-22). Note that new wastewater was used on day 8 and on day 16. Even without replacing the GCA, the reduction rate on the second and third phase was found to be lesser by only around 13% and 9% respectively compared to that of the first phase. This suggests that GCA was still able to reduce phosphate even after being already used. The exposure to oxygen during dewatering and air-drying allowed the GCA to recover.

b) Ammonia

Levels of ammonia (NH_3) decreased significantly with some cases even being untraceable by the photometer. For the wastewater used in Day 1 to Day 7, the initial concentration of ammonia (without GCA) was measured to be 10.63 mg/L as shown in Figure 2a. Comparing with the results of the experimental cases with GCA on Day 1, the initial ammonia on Day 0 measurement for the wastewater was higher. After 7 days of contact with GCA, ammonia was reduced. Consequently, levels of nitrate (NO_3^-) increased as seen in Figure 3. As each phase is replenished with new wastewater, results of Day 1-7, Day 8-14, and Day 16-22 are presented separately

Reduction of ammonia is possible when oxygen is present to proceed with ammonification. Figure 2 shows that DO levels increased after 7 days. This can be due to the elution of oxides which may form oxygen. As DO levels increase, conversion of ammonia to nitrite is favorable. Moreover, conversion of nitrite to nitrate is also favorable with the presence of oxygen, allowing nitrogen cycle to start. Figure 3 shows the increase in nitrate after conversion of ammonia to nitrite together with the increase in dissolved oxygen.

It should also be noted that new wastewater was used at the start of Day 8 and Day 16, without replacing the GCA initially used. Results showed that GCA still had the capacity to still reduce the ammonia on the second and third phase despite it being already used. The recorded reduction rate in phase 3 only differed by 3% and 5% compared to that of phase 1 and phase 2 respectively which could be still considered ass an efficient reduction rate. A summary of the reduction rate of ammonia is shown on Table 2.

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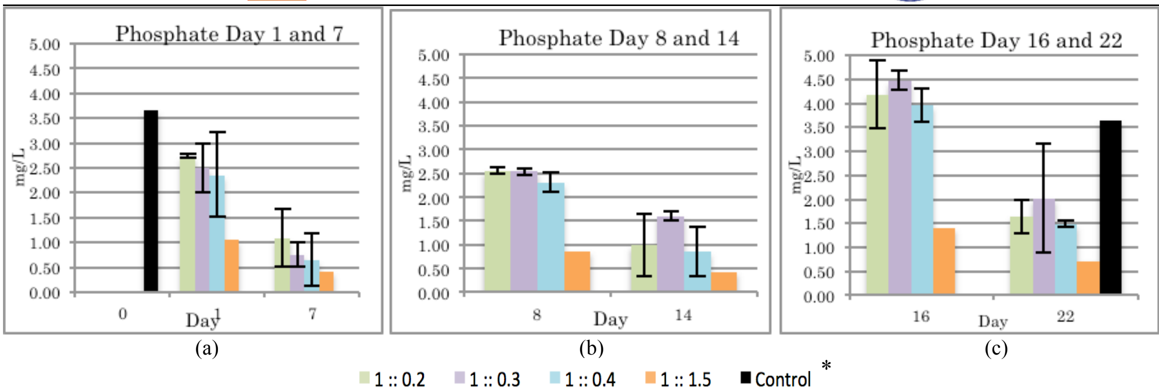

Figure 1. Phosphate concentration on (a) Day 1 and Day 7, (b) Day 8 and Day 14, (c) Day 16 and Day 22
* Ratio of wastewater to GCA by volume

Table 1. Average Reduction Rate of PO_4^{3-}

Reduction rate	Phase 1: Day 1 to 7	Phase 2: Day 8 to 14	Phase 3: Day 16 to 22
PO_4^{3-}	66%	53%	57%

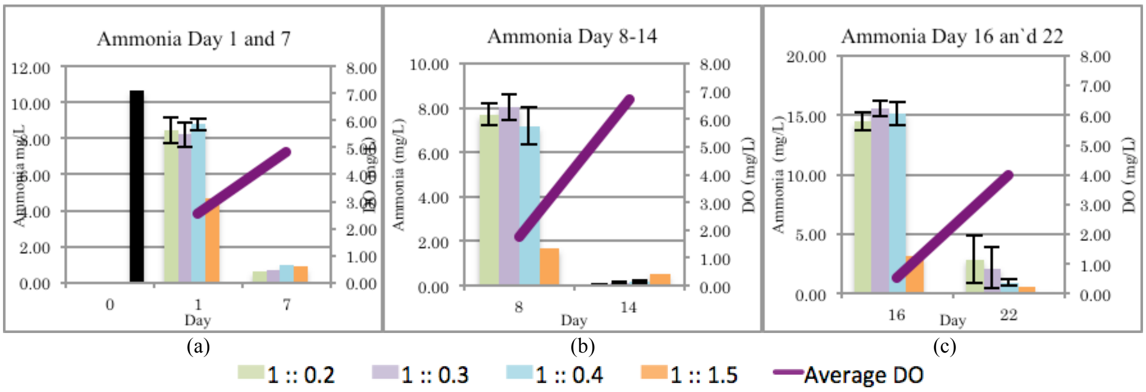

Figure 2. Ammonia concentration on (a) Day 1 and Day 7, (b) Day 8 and Day 14, (c) Day 16, 22, and 28

Table 2. Reduction Rate for NH_3

Reduction rate	Phase 1: Day 1 and 7	Phase 2: Day 8 and 14	Phase 3: Day 16 and 22
NH_3	89%	91%	86%

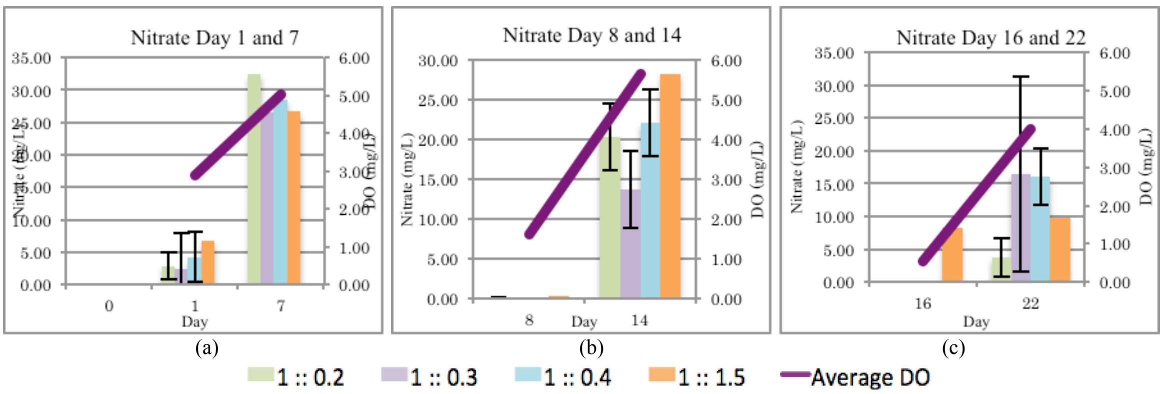

Figure 3. Nitrate concentration on (a) Day 1 and Day 7, (b) Day 8 and Day 14, (c) Day 16 and Day 22