Development of Silica Gel from Rice Husk and Evaluation of its Applications

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Abstract - Rice husk was used to extract silicon since it has a very high silicon content. Therefore, this research was conducted to convert rice husk into silica gel by developing a process. Cleaned rice husk was burned in a muffle furnace at 600°C for 6 hours to get ash. Ash was dissolved by potassium hydroxide (1.425 M, 150 mL) and heated for 20 minutes at 100°C. The solution was filtered and 5 mL of phosphoric acid was added to the filtrate to get the silica gel. Rice husk ash and the silica gel were analyzed for biological and biochemical parameters. Prepared silica gel showed an alkali pH of 9.59. Germination percentage of control treatment and treatment with 1% silica gel was 68% and 43%, respectively in bioassay. Organic solution was prepared using CO-3 grass. It was used to adjust the parameters of the silica gel. A mixture of silica gel and the organic solution was analyzed for different parameters for 7 days. The initial parameters of the mixture changed and reached static values. After 7 days, pH, electrical conductivity, salinity, and total dissolved solids (TDS) of the mixture were 9.59 to 8.56, 14.68 to 5.28 mS/cm, 8.4 to 2.7 ‰, and 8,230 to 2,710 mg/L, respectively. Adsorption kinetics was applied to the mixture and 12.97 times transformation of TDS took place in the mixture. A huge portion of TDS transformed into available form. Different organic solutions can be used to check the TDS transformations and concentrated organic acid could replace phosphoric acid.

Keywords: Rice husk, Silica gel, Phosphoric acid

I. INTRODUCTION

Rice husk is a by-product of rice processing industry. Very large amount of rice husk is produced annually in Sri Lanka. This produced rice husk is mainly used as an energy source in Sri Lanka in many industries where they need high amount of heat. Silicon (Si) is the second richest element on the earth's surface which can provide substantial benefits for many crops, particularly greenhouse crops since our soils have less substrate and do not contain much available silicon. It is very common to use silicon fertilizers in soil less culture (hydroponics) as foliar or root application, but there are significant benefits to the crops if it is used in soil cultures too. It can act as a reinforcement of cell walls by deposition of solid silica. In addition to naturally occurring soluble Si in soil, many crops respond positively to additions of supplemental Si. Plants especially grasses, can up take large amount of Si which it contributes to their mechanical strength [1]. However, an effective method of application of Si is one of the problems for the farmers, whether to apply as a foliar application or root application because of the uncontrollable factors. Rice husk ash is a good silicon pool. So, developing a process to convert the Silicon in the rice husk ash into an available form for the plants will be the best option to solve environmental pollution while harnessing the economic benefits.

II. MATERIALS AND METHODS

The process was started using the rice husk as the raw material. Fresh rice husk was collected from a rice processing centre. The research was conducted in the Soil and Water Engineering Laboratory of Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya. Collected rice husk was cleaned to remove the inert materials soon after collection. Cleaned rice husk was burned in a muffle furnace at 600°C for 6 hours to get ash. 10 g of rice husk ash was measured and put into a conical flask. 150 mL of prepared potassium hydroxide (1.425 M) solution was poured into the conical flask and stirred using a magnetic stirrer. The solution was gently heated in the water bath (100°C) for 20 minutes. The heated solution was filtered using a Whatman No 1 filter paper. 5 mL of pure Phosphoric acid was added to the filtrate soon after filtering. The solution was shaken well by hand. The gel was obtained while shaking. Rice husk ash and the silica gel were analysed for the parameters of pH, electrical conductivity, salinity, total dissolved solids (TDS), total suspended solids (TSS) and volatile solids (VS). Organic solution was prepared using CO-3 grass. It was used to adjust the parameters of the silica gel. The surface of the silica gel was fully covered with the organic solution in the parameter adjustment test mentioned above. Adsorption kinetics was applied to the mixture as the process more likely to an adsorption process. Eq. 1 (Elements of Chemical Kinetics, 1970) was used for the calculation.

$$v = k\,\frac{\lambda_A \times P_A}{1+\lambda_A \times P_A} \qquad \text{Eq. 1}$$

Where, v = Rate of reaction, λ = Inverse of the ratio of available TDS, absolute TDS (B/A), P = Specificity, and k = constant. Absolute TDS of the solution and the available TDS of the solution were calculated with the collected data. The inverse value of the ratio of available TDS and absolute TDS was calculated which was given the λ value. The value for v was calculated using those λ values. Bioassay studies with

Table 1: Measured Parameters of Silica jel

Parameters	Replicate 1	Replicate 2	Replicate 3	Average
pH	9.59	9.53	9.66	9.59±0.05
Electrical conductivity (mS/cm)	15.72	14.04	14.28	14.68±0.74
Salinity (‰)	9.1	8.0	8.1	8.4±0.49
TDS (mg/L)	8,980	7,890	7,820	8,230±531.09
TSS (mg/L)	214	144	178	178.67±28.58
VS (mg/L)	160	96	136	130.67±26.39

different silica gel percentages were conducted to check the phytotoxicity of the silica gel. Lettuce seeds and Tomato seeds. Germination percentages of each treatment were measured after seven days.

III. RESULTS AND DISCUSSION

The measured quality parameter values of the prepared rice husk ash and silica gel showed some variations from the literature. Rice husk was selected to prepare the silica gel because the available quantity of rice husk is very high in Sri Lanka [2]. Si is available in a readily available form of rice husk ash too. The mass conversion ratio of rice husk to rice husk ash is about 20% according to the literature [3]. But in this experiment, it was around 14.93± 0.9%. There could have been an instrumental error and the Replicate 3 could be considered as an outlier or simply the new varieties may have low ash contents since the thickness of the husk is very small. KOH is used to prepare the silica gel instead of NaOH as KOH is having many advantages over NaOH. The use of KOH is good to incorporate K^+ ions into the soil which is an essential nutrient for the plants. The exchangeable Na^+ adversely affects the physical and nutritional properties and the growth of the plants.

Prepared silica gel has an alkali pH of 9.59 (Table 1). The TDS value of the prepared silica gel is comparatively high and it is due to the high availability of ions. The average mass conversion value is 82.3% which is higher than the reported value of 73.1% [4]. The first bioassay failed and germination percentage of control treatment and treatment with 1% silica gel was 68% and 43%, respectively in the second bioassay. Bioassay studies show the concentration of the silica gel has an effect on germination. A high concentration of the silica gel made a negative impact on the germination of the seed. 0 – 1 % of the gel is better than at higher concentrations to be used as a soil application. parameters of silica gel, particularly the pH is high in terms of it as a fertilizer. So, the parameters must be adjusted using the organic solution to a certain preferable level. The amount of nutrients present in CO-3 is high compared to other types of biomasses. pH, electrical conductivity, salinity, and TDS values of the sap were 6.12, 5.32 mS/cm, 2.8 ‰ and 2790 mg/L respectively. A mixture of silica gel and the organic solution was analysed for different parameters for 7 days. The initial parameters of the mixture changed and reached static values. After 7 days, pH, electrical conductivity, salinity, and TDS of the mixture were 9.59 to 8.56, 14.68 to 5.28 mS/cm, 8.4 to 2.7 ‰, and 8,230 to 2,710 mg/L, respectively. At the same time, the organic solution adsorbed into the gel surface had a high portion of TDS transformed into the solution. Adsorption kinetics was applied to the mixture and 12.97 times transformation of TDS took place in the mixture. The available portion of the TDS relates with the available number of ions. So, the ions for the uptake of the plant are increased once the gel is treated with the organic solution.

IV. CONCLUSIONS

Mass conversion of the silica gel from rice husk ash is much higher. Very high amount of Silica was converted using rice husk ash and KOH with an average of 13.33 litres per kg of rice husk ash. Important parameters of pH and ionic strength of the silica gel were adjusted using the prepared organic solution from CO-3 grass. An extremely high quantity of TDS was made available from the gel when it was incorporated with an organic solution. Adsorption kinetics indicates rapid transformations with available active sites. Further studies should be undertaken with different organic solutions to check the quality changes of the silica gel. Phosphoric acid can be replaced with organic acids with the required concentration to make use of conversions to TDS. Bioassay should be undertaken with the organic solution treated silica gel and also with the diluted silica gel. Silica gel can be incorporated to biofertilizer granules.

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