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Solubilization of Potassium from Gluconite by Microorganisms

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Abstract

The current study was conducted to explore the potential of potassium solubilizing for the plant from Gluconite Egyptian ore. *Thiobacillus thiooxidans*, *Rhizobium leguminosarum*, *Rhizobium rhizogenes* and *Bacillus megaterium* were evaluated for their ability to potassium dissolution from Egyptian Gluconite ore by studying optimization conditions of incubation temperature, incubation time and inoculum size, pH and different carbon and nitrogen as energy sources. Results revealed that dissolution of potassium reached to 30.66, 31,66, 34.44 and 28.87 for *Thiobacillus thiooxidans*, *Rhizobium leguminosarum*, *Rhizobium rhizogenes* and *Bacillus megaterium* respectively. A model has been suggested which assumes that the potassium was attacked by the reducing bacteria to produce potassium ions of produced organic acids. Kinetically, the leaching process was a zeroorder reaction. In this work applied of microorganism in industrial processes was practically feasible with low cost and friendly environmental process.

Keywords: Gluconite, Potassium dissolution bacteria
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1. Introduction

Among the three essentials nutrients required by plants, one of them is Potassium. It is available in four forms in the soil which are K ions (K^+) in the soil solution, as an exchangeable cation, tightly held on the surfaces of clay minerals and organic matter, tightly held, and present in the lattice of certain K-containing primary minerals. Potassium though presents in as abundant element in soil or is applied to fields as natural or synthetic fertilizers, only one to two percent of this is available to plants, the rest being bound with other minerals and therefore unavailable to plants. The most common soil components of potassium, 90 to 98%, are feldspar and mica [1].

Certain soil microorganisms (bacteria, fungi) are capable to dissolve insoluble potassium. *Enterobacter hormaechei* has capability as Potassium-solubilizing bacteria (KSB) since they produce Oxalic acid and citric acids and specific enzyme [2]. KSB could serve as inoculants. They convert insoluble potassium in the soil into a form that plants can access. Inoculation with A potassium-releasing bacterial strain *Bacillus edaphic* NBT was found to increase root and shoot growth of cotton and rape. Strain NBT was able to mobilize potassium efficiently in both plants when it was added to the soil [3].

Research and Development Centre for Mineral and Coal Technology conducted a number of researches regarding the beneficiating K-bearing silicate rocks during 2012 [4]. The researches focused on upgrading the K content available for plant within the rocks. Some minerals, for example K- feldspar ($KAlSi_3O_8$); Leucite ($KAlSi_2O_6$) and trachyte, were used as raw materials for K-fertilizers. Based on data from Center for Geological Resources, there is a K-mineral reserve in Situbondo Regency, East Java Indonesia and Payak Central Java. The mineral is leucite or $KAlSi_2O_6$, in addition to K- mineral resources, trachyte that spreads out in

South Sulawesi is available in District of Barru. In this research, the insoluble potassium sources refer to tekMIRA analysis.

2. Materials and methods

Gluconite

The gluconite ore obtained from New Valley run of mine with composition: 0.654% Na_2O, 2.765% MgO, 6.069% Al_2O_3, 34.551% SiO_2, 0.63% P_2O_5, 0.348% SO_3, 6.881% K_2O, 0.991% CaO 0.052% Co_3O_4, 0.048 ZnO, 0.031% GeO_2, 0.021% SrO, 0.027% ZrO, 0.0894% Cl, 0.0506% TiO_2, 0.194% MnO, 35.606% Fe_2O_3, and 10.3% loss of Ignition. The sample contained the following minerals composition: Celdonite $K(Fe, Al)_2(Si, Al)_4O_{10}(OH)_2$ monoclinic.

Microorganisms and growth media

Four microorganisms as *Thiobacillus thiooxidans*, *Rhizobium leguminosarum*, *Rhizobium rhizogenes* and *Bacillus megaterium* obtained from were purchased from Microbial Wealth Center - Faculty of Agriculture - Ain Shams University used to evaluate their Potassium dissolution efficacy of Gluconite ore.

Culture media: Different types of culture media are used for microbial growth and dissolution activity assay throughout the practical study of this work, which are: Pikovskaya's medium (PVK) It contains (g/l): 0.5 g/l Yeast extract, 10 g/l Dextrose, 5 g/l Tri calcium phosphate, 0.5 g/l Ammonium sulphate, 0.2 g/l Potassium chloride, 0.1 g/l Magnesium sulphate, 0.0001 g/l Manganese sulphate and 0.0001 g/l Ferrous sulphate. Suspend 16.3 grams in 1000 ml distilled water. Heat if necessary to dissolve the medium completely and sterilize by autoclaving at 1.5 pressure (121°C) for 15 minutes. Dispense as desired. This medium is solidified by adding 15 g agar per liter [5].

Modified 9 k medium: as described in (El Barbary et al., 2015) [6].

Ashyb's medium as described by (El Badry et al., 2016) [7].

Experiment method: as described in (El Badry et al., 2016) [7]

3. Results and discussion

Effect of initial pH on potassium dissolution

A series of experiment was carried out under the following condition (ore amount 0.25, temperature of 30°C, peptone as nitrogen source and beef extract as carbon source, cell count is 0.1×10^{29} cfu) the pH studied from 4 up to 8) after the incubation time the potassium for the four microorganisms were measured to define each of the are the more suitable for dissolution. Figure 1 described the effect of pH on dissolution of potassium. It was found that 19.88, 20.88, 22.72 and 19.05 % potassium recovery by using *Thiobacillus thiooxidans* (Tt), *Rhizobium leguminosarum* (Rl), *Rhizobium rhizogenes* (RR) and *Bacillus megaterium*(BM) respectively with same PH value equal 7 for all microorganisms *R. rhizogenes* with 22.72% potassium dissolution was the most potent organisms by this results it was the foirst time to evaluate *R. rhizogenes* in potassium dissolution from gluconite rather than *Bacillus megaterium*, *Rhizobium leguminosarum* and *thiobacillus thiooxidans* which ordinary used in potassium dissolution. Kang et al. [8], 2014 evaluated potassium dissolution ability of *B. megaterium* which enhanced by optimal culture conditions at pH 7.0 and 35 °C which might be due to the presence of malic in the culture medium wherease for many years T. ferrooxidans was considered to be the most important micro-organism in commercial bioleaching and biooxidation plants that operate at 40 °C or less [9].

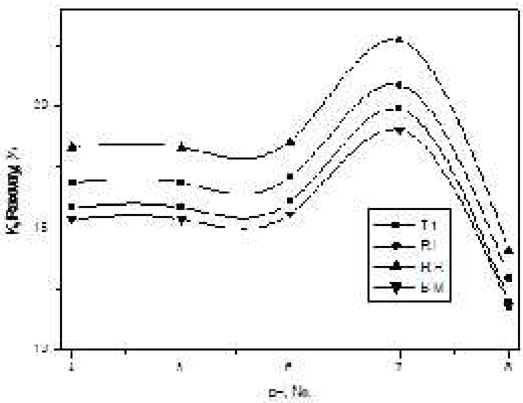

Fig (1): Effect of initial pH on potassium dissolution from Gluconite ore.

Effect of ore amount on Potassium dissolution

The effect of the ore amount of gluconite gram on the extent of bioleached potassium is graphically demonstrated in Figs 2. It was seen that the extent of leached potassium decreases with the increase in the weight of gluconite ore, and increases with time attaining an optimum at 30 h. It is seen that the extent of leaching directly depends on the weight ratio of the selected microorganism to the weight of the gluconite ore subject to leaching as given in Figure 2. The results had obvious changes in potassium dissolution by 24.54, 25.54, 27.79 and 23.3 % using *Thiobacillus thiooxidans*, *Rhizobium* *leguminosarum*, *Rhizobium rhizogenes* and *Bacillus megaterium* respectively. The dissolution of potassium from gluconite decreases with increasing ore concentration in the growth medium, that may be attributed to toxic effect of some metal ions which may be released into the culture medium such as Mn^{+2} and Na^{+1}, Ca^{+2} ions and these ions can react with soluble acid anions and form insoluble salts so decrease total soluble potassium, these results found to be almost similar to that obtained by (Hefnawy et al., [10]. Also, it may be due to inhibitory effect on further potassium solubilization, the negative effect of soluble potassium on microbial acid productivity [11] might also be responsible for final soluble potassium concentration. Another explanation for this might be formation of an organic compound induced by organic metabolites released, which in turn, reduces the amount of available potassium [12].

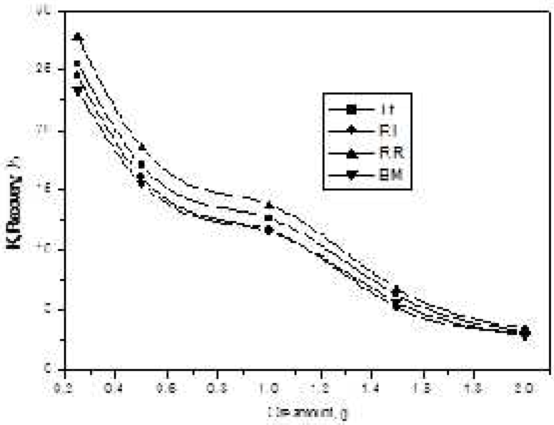

Fig (2): Effect of ore amount on potassium dissolution from gluconite ore.

Effect of inoculum size on potassium dissolution

The Effect of inoculum size on the potassium dissolution from gluconite ore from 0.5 $x10^{29}$ up to 3 x 10^{29} plotted in figure 3. The results revealed that the dissolution of potassium from gluconite ore reached to 24.88, 25.88, 28.16 and 23.60 % with *Thiobacillus thiooxidans*, *Rhizobium leguminosarum*, *Rhizobium rhizogenes* and *Bacillus megaterium* respectively.

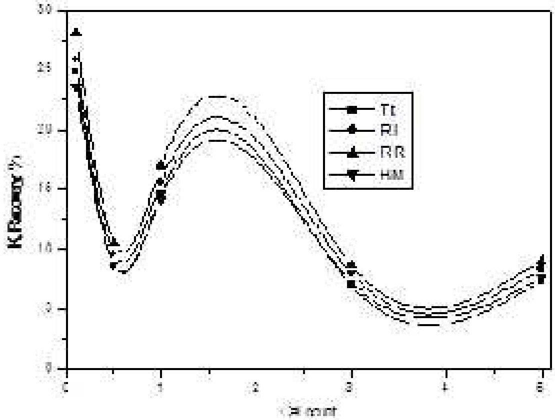

Fig (3): The effect of cell count on the Potassium dissolution from gluconite ore.

Effect of temperature on the potassium dissolution

The effect of temperature on the dissolution of Potassium from gluconite ore was evaluated after 30 hr of reaction. It is seen that the extent of bioleaching is favored at temperatures 30°C after 30h in the incubator and represented in figure 4. From Figure 4 it was found that the four bacteria dissolve potassium from the ore as 27.17, 28.17, 30.64 and 25.69 % with *Thiobacillus thiooxidans*, *Rhizobium leguminosarum*, *Rhizobium rhizogenes* and *Bacillus megaterium* respectively. The growth of Bacterium at 30°c refers to mesophilic bacterium which grows best in moderate temperature, neither too hot nor too cold [13].

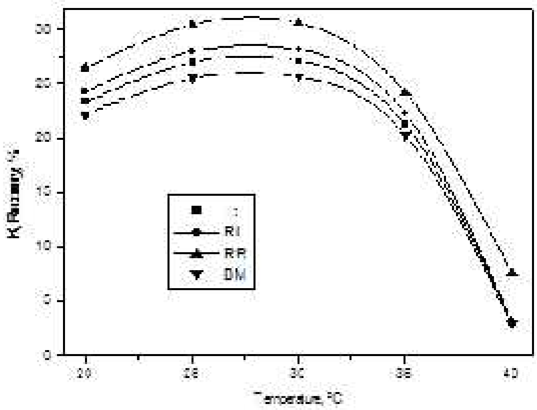

Fig (4): Effect Temperature on the extent of bioleaching the potassium from gluconite ore

Effect of different Nitrogen as Energy source on the potassium bioleaching

The effects of nitrogen as energy source on the dissolution of potassium of gluconite ore, 5 nitrogen sources are used (Ammonium chloride, Ammonium sulphate, Ammonium oxalate, Asparagine and Glycine) to study the effect after 30 h of reaction. It is seen that the extent of bioleaching is favored with ammonium oxalate as nitrogen energy source. This result agrees with (El badry et., [7]). From the plot it was found that the best nitrogen energy source with the four microbe is ammonium oxalate where it gives 29.63, 30.63, 33.33 and 27.94 % with *Thiobacillus thiooxidans, Rhizobium leguminosarum, Rhizobium rhizogenes* and *Bacillus megaterium* respectively.

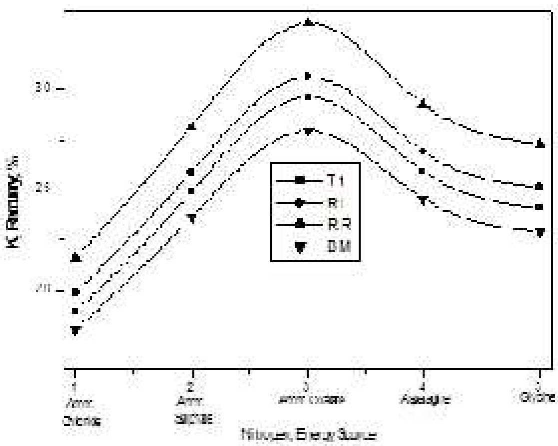

Fig (5): Effect Nitrogen as Energy source on bioleaching of potassium from gluconite ore.

Effect of different Carbon as Energy source on the potassium dissolution

The effect of different carbon as energy source on the potassium dissolution from gluconite ore four sources of Carbon Sources are used Glucose, Starch, Sucrose and dextrose. The results are plotted in figure 6. Results revealed that Glucose is the most suitable carbon Energy source with the three microbe is where it gives 30.66, 31.66, 34.44 and 2.87 with Thiobacillus thiooxidans, Rhizobium leguminosarum, Rhizobium rhizogenes and Bacillus megaterium respectively which agree with El badry et al. [7, 14].

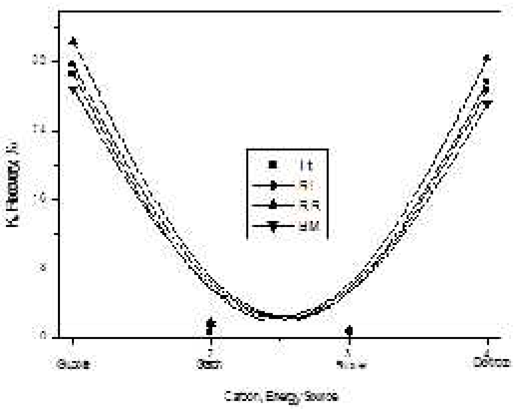

Fig (6): Effect Carbon as Energy source on the potassium bioleaching from gluconite ore.

3. Conclusion

It is concluded that bioleaching of potassium depends on different influential factors in the premise that *Rhizobium rhizogenes* is most suitable microorganisms for dissolution of potassium from gluconite ore. It helps to convert the potassium present in the gluconite ore to dissolved salt that the plant can easily use it.

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