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Effect of Gamma Irradiation on Phosphorus Removal from an Algerian Iron Ore of Gara Djebilet

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ABSTRACT

Phosphorus, along with other undesirable elements, is an extremely deleterious constituent present in iron ores utilized as the raw material in the steel production process. It is responsible for increasing the hardness and brittleness of steel while reducing its ductility. The iron ore of Gara Djebilet has been the subject of several dephosphorization and enrichment studies. In this work, we are tested a new method for the dephosphorization of iron ore, which consists of irradiated ore with gamma irradiation, which possesses sufficient energy to potentially cleave the bonds between iron and phosphorus. Thermal pre-treatment can improve the efficacy of dephosphorization, we chose to roast the samples at 800°C followed by leaching with sulfuric acid. Mineralogical analyses including XRF, XRD, SEM and UV spectroscopy were conducted to identify the mineralogical phases. To optimize the parameters influencing the treatment and reduce the number of experiments, a Box-Behnken design of experiments was implemented and allowed assessment of the technique's efficacy. The treatment parameters optimized in this work were roasting temperature (300-800°C), sulfuric acid concentration (0.2-1N) and gamma irradiation dose (20-100 kGy). The two measured responses were the phosphorus removal percentage and iron enrichment percentage. The irradiated iron ore was leached with sulfuric acid solution after roasting the iron ore at the appropriate temperature. The optimization results confirm the model is significant. The optimal conditions proposed by the model for Gara Djebilet iron ore dephosphorization within the selected ranges are: a roasting temperature of 800°C, 0.6 N sulfuric acid and an irradiation dose of 100 kGy. Gamma irradiation is enabled to reducing the roasting temperature, but also decreasing the concentration of sulfuric acid. However, the obtained dephosphorization rate remains appreciable at over 53%.

Keywords: Iron ore, Gara Djebilet, phosphorus removal, gamma irradiation.

1. Introduction

The Gara Djebilet deposit is located approximately 140 km southeast of Tindouf. The geological characteristics of the deposit are schematically represented by three layers. Layers D1 and D3 are non-ferromagnetic and have a high silica concentration, while layer D2, predominantly ferromagnetic, characterized by iron and phosphorus contents of 54% and 0.8%, respectively. The Gara Djebilet deposit is not exploited due to its high phosphorus content and especially, its oolitic structure. The iron ore at Gara Djebilet is present in various minerals. Phosphorus is present in the form of apatite and structures containing iron and phosphorus [1]. Reducing the phosphorus content is the main concern, as this would enable its development and production. Many studies have been conducted to find a technically and economically viable solution to reduce the phosphorus content to a level suitable for industrial exploitation [2].

2. Experimental

To evaluate the effect of the three independent variables on the percentage of phosphorus removal and the percentage of iron enrichment from an Algerian iron ore of Gara Djebilet, without the need to make a considerable number of experimental trials, we applied a three-level Box-Behnken experimental design with

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15 experimental trials [3]. The studied factors were: irradiation dose (x1), sulfuric acid concentration (x2) and roasting temperature (x3). Therefore, the aim is to reduce the phosphorus content at least 0.1% with high iron content. The levels (-1), (0) and (+1) are presented in Table I.

Table I : *Variables and experimental domains of phosphorus removal and iron enrichment process parameters in the Box-Behnken experimental design*

	Level (-1)	Level (0)	Level (+1)
Irradiation dose (kGy)	20	60	100
Sulfuric acid concentration(N)	0.2	0.6	1
Roasting temperature (°C)	300	550	800

The irradiated iron ore was leached with sulfuric acid solution after roasting the iron ore at the appropriate temperature. The amount of eliminated phosphorus from the leachate was evaluated spectrophotometrically at 725 nm and the percentage of iron enrichment was determined by Energy dispersive X-ray fluorescence (ED-XRF).

3. Results and Discussion

The three-level Box-Behnken experimental design corresponded to 15 experimental trials that allowed to obtain different percentage of phosphorus removal and the percentage of iron enrichment, which varied respectively in the range values from 11.7% to 53.04 and 3.33 to 10.67%. The higher value of phosphorus removal was 53.04 % obtained when irradiation dose (x2) and roasting temperature (x3) were in higher levels (+1) and sulfuric acid concentration was in level (0) (Fig 1). The contrast can be classified in order of significance, from the higher influential to least influential, based on their absolute numeric values as follow:irradiation dose :irradiation dose (x1x1)> irradiation dose:roasting temperature (x1x3)> roasting temperature (x3)> irradiation dose:sulfuric acid concentration (x1x2)> irradiation dose (x1)> sulfuric acid concentration (x2).

The higher value for iron enrichment was 10.67 % obtained when irradiation dose (x1) and sulfuric acid concentration (x2) were in lower levels (-1) and roasting temperature (x3) was in level (0) (Fig 2), only the irradiation dose was more efficient at the low dos

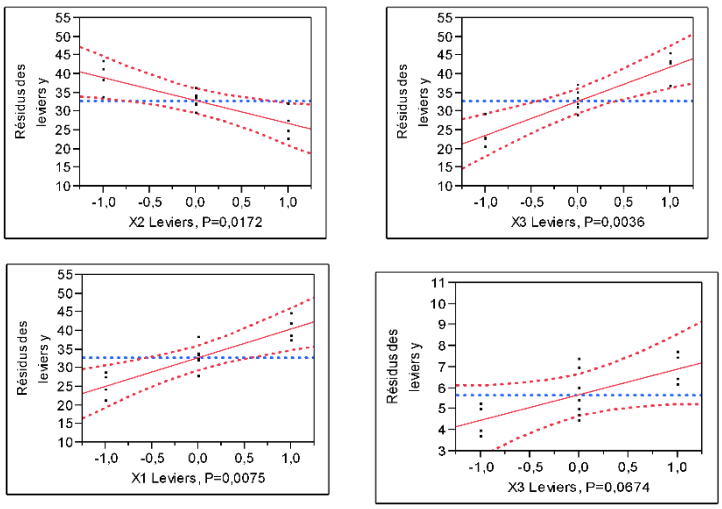

Figure 1: Plots of main effects of three factors on the phosphorus removal.

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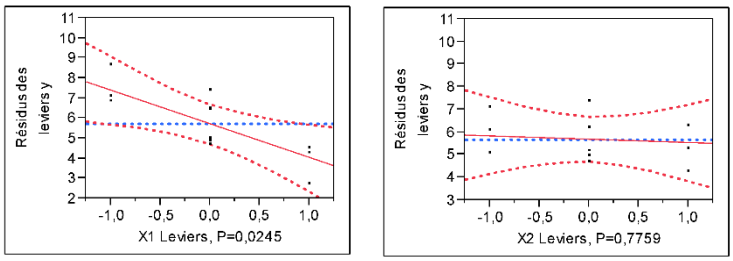

Figure 2: Plots of main effects of three factors on the percentage of iron enrichment.

4. Conclusions

The application of a the three-level Box-Behnken experimental design method to establish mathematical model proved to be a very effective method and helpful to investigate irradiation dose, sulfuric acid concentration and roasting temperature on phosphorus removal and iron enrichment process from an Algerian iron ore of Gara Djebilet. The study showed that all the three factors and as well as their interaction is significant in the phosphorus removal process, and can be classified in order of significance. Irradiation dose was the more significant action followed by roasting temperature and sulfuric acid concentration. The interaction effects between the three factors can also play a significant effect in the phosphorus removal process. Using 100 kGy, 0.6 N of sulfuric acid and 800 °C of roasting temeperature, can reach 53 % of phosphorus removal from Algerian iron ore of Gara Djebilet.

References

[1] Zajnullin L., Karelin V., Epishin A., Kai C., Malikbaev B., Iron ore dephosphorization of gara djebilet deposit by hydrometallurgical method. KnE Engineering, 3(5), 2018)168.

[2] Sparks B.D., Sirianni, A.F., (). Beneficiation of A phosphoriferous iron ore by agglomeration methods. Journal international du traitement des minerais, 1(3), 1974. 231.

[3] Goupy J., Creighton L., Introduction aux plans d'expériences. édition Dunod. 2006. 180

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